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CABBAGE APHID ASSESSMENT AND DAMAGE IN ENGLAND AND WALES, 1946-55

Contribution from the Conference of Advisory Entomologists, National Agricultural Advisory Service, summarized by A. H. Strickland of the Plant Pathology Laboratory, Harpenden, Herts

A summary of the first three years of field plot work on the Cabbage aphid, *Brevicoryne brassicae* (L.), together with full experimental details, has already been published (Strickland, 1954). Further trials were carried out at five sites (Ramsgate, Kent ; Mickleton, Gloucestershire ; Botley, Hampshire ; Biggleswade, Bedfordshire ; and Longbenton, Northumberland) in 1954, and at one site (Biggleswade) in 1955. The 1954 results were useful in providing data on yields in an exceptionally wet year when aphid density was lower than at any time since the inception of this work, and the data from Biggleswade in 1955 were particularly valuable because this was only the fourth time in 25 trials that a moderately high aphid density developed on the untreated plots. With field trial results available for five seasons—three of them near average climatically, and the other two years with contrasting extremes of climate—and Extensive Survey data covering the Brussels sprout growing areas of England and Wales available for the ten-year cycle from 1946 to 1955, a comprehensive summary of work on yield loss in sprouts caused by Cabbage aphid can now be presented.

In preparing this summary and condensing a great mass of data, much use has been made of averages. In particular, mean aphid densities have been calculated for certain stages in the growth of the host plants which are themselves averages of growth at several sites. To refer, for instance, to an average aphid density of 1·28 in August throughout England and Wales is to suggest that this density was actually detected throughout the country. Such was, in fact, the case, but it is not possible to interpret this figure in relation to the effects the aphids have on the host plants, unless something is also known about the stage of growth reached by the plants in different parts of the country. For this reason, the data have been collated in terms of the length of time the host plants have been standing in the field, since, in general, if seedling plants of similar age are planted on, say, June 1 and June 15 respectively, they will be at about the same level of maturity on July 15 and August 1 respectively. In this paper, then, the term " early peak " refers to the maximum aphid density observed on the experimental plants 6–8 weeks after they were planted out in the field, irrespective of the calendar date on which they were planted, and " seasonal peak " refers to the maximum density noted after the plants had been growing away for 12–14 weeks. In general, the early peak is reached about the middle of July and the seasonal peak about the middle of September.

One further point needs emphasis before the results are discussed. Commercial sprout growers often look on Cabbage aphid as a nuisance from a purely mechanical point of view. If high densities develop in September, individual aphids tend to colonize the growing sprout buds, and the sprouts themselves are physically contaminated with aphid detritus at harvest and may be unsaleable. This has been noted in only four of the field trials. Nevertheless, the yield results are of considerable interest, because they show the extent to which early

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and mid-season aphid infestations have a physiological effect on the sprout plants and lead to a loss which escapes the notice of the grower.

FIELD PLOT RESULTS

In two of the trials, only a single insecticide treatment was given—on June 22, 1953, (Norton, Kent) and May 23, 1954 (Mickleton, Gloucestershire). Fourteen trials received two treatments, the first about June 17 and the second about August 13, and four received a third application about July 22. Five of the trials had to be discarded for reasons beyond the control of those in charge of them.

Three-leaf sample counts for aphid density assessments were made at two- or four-weekly intervals throughout the season, at all sites, every year. Sampling dates did not, of course, coincide from year to year, or even from site to site, in any one year. However, by bulking all the results, it has been possible to arrive at approximate average aphid density values for the months June to October inclusive, and these are set out in Table 1.

TABLE 1

MEAN LOG (N + 1) APHID DENSITY PER SAMPLE, JUNE TO OCTOBER

Month	Average Date on which Samples were Taken	Mean Log (N + 1) Aphid Density per Sample	
		Untreated Plots	Treated Plots
June	21 ± 2	0·16 ± 0·09	0·13 ± 0·08
July	18 ± 2	0·86 ± 0·16	0·27 ± 0·09
August ..	15 ± 1	1·28 ± 0·20	0·44 ± 0·12
September ..	13 ± 2	1·29 ± 0·15	0·45 ± 0·10
October ..	14 ± 2	0·73 ± 0·13	0·17 ± 0·05

Generally, treatment with a systemic insecticide in the middle of June reduced the average July density of aphids from about six to about one per sample, and an additional application in the middle of August reduced peak density in September from about eighteen to approximately two per sample.

A relationship between aphid density on plots receiving insecticide treatment and on those receiving none was noticed. Treatments were not completely efficient, and at any given time after application there was a small number of aphids present on the treated plants. These comprised survivors and their progeny, as well as migrant alatae at certain times in the season. These aphids reacted to biological and climatic impulses in the same way as those on untreated plants. In short, if conditions were appropriate for a rapid increase in density, there was a rapid increase in the number of aphids on both treated and untreated plants. This is illustrated by data from Harlow, Essex, in 1952. Demeton was applied to the treated plots on July 14 and September 2, and the aphids reacted as shown in Table 2.

In this instance, dry weather in July hindered absorption of the insecticide and, after an initial knock-down on the 14th, the treated-plot survivors increased in density side by side with the aphids on the untreated plots, until rain, early in August, brought soil-bound insecticide into contact with the roots of the sprout plants. During September, aphids on the untreated plots decreased in density, and by the middle of October very few live specimens could be found. At the same time, the few aphids which survived treatment on September 2

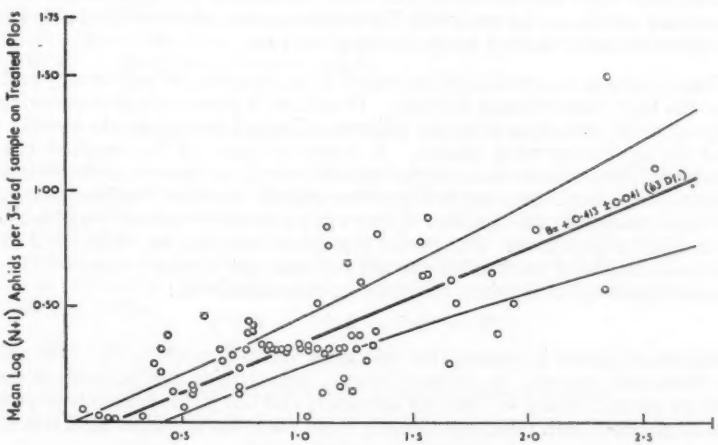
were unable to survive the combination of environmental factors which eventually eliminated the infestations on the untreated plots.

TABLE 2

APHID DENSITIES ON TREATED AND UNTREATED PLOTS, HARLOW, 1952

Date	Mean Log (N + 1) Aphids per Sample	
	Untreated Plots	Treated Plots
July 11 ..	1·74	1·32
17 ..	1·89	0·15
24 ..	2·36	0·82
31 ..	2·88	1·81
August 7 ..	2·95	1·19
21 ..	3·30	0·71
September 4..	3·11	0·58
18..	1·15	0·01
October 3 ..	0·93	0·00

In an attempt to determine the relationship between the behaviour of aphid populations on treated and untreated plants, the appropriate means for all plots, sites, and years have been analysed. The result is shown in the figure below, which gives the scatter of the readings expressed as deviations from site means, as well as the overall regression, and five per cent fiducial limits for aphids per sample on treated plots, on aphids per sample on the untreated plots. It is evident that more aphids survive treatment when density is high than when it is low.



Regression of aphid density on plots treated with systemic insecticides on aphid density on untreated plots. Data have been bulked for four years, and differences due to variation between sites and years have been eliminated. The curved lines show the appropriate 5 per cent fiducial limits.

Results from all sites and years have been used to compute overall and partial regression coefficients for yield on aphid density early in the season, and

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at peak density which is usually reached in September. The within-site overall coefficients for four years are given in Table 3.

TABLE 3

REGRESSION COEFFICIENTS FOR YIELD, EXPRESSED AS LB OF MARKETABLE SPROUTS PER PLOT OF 100 PLANTS, ON LOG (N + 1) APHID DENSITY PER THREE-LEAF SAMPLE, FOR FOUR YEARS

Year	Degrees of Freedom	Coefficients at Early Peak	Coefficients at Seasonal Peak
1952	73	− 29·21 ± 6·03	− 20·10 ± 3·61
1953	70	− 15·61 ± 5·21	− 14·97 ± 3·61
1954	45	− 19·11 ± 7·54	− 2·88 ± 5·39
1955	13	− 18·12 ± 10·85	− 9·06 ± 3·85
All four years	204	− 20·56 ± 3·30	− 14·86 ± 2·09

The seasonal peak coefficient for 1954, and the early peak value for 1955, are the only two in the table which do not differ significantly from zero. In view of the exceptionally low peak aphid density in 1954, it is also not surprising that the coefficient for this year differs significantly from that for the seasonal peak in 1952, a year in which aphid density was moderately high. Undue weight should not be given to the 1955 values, which are based on data from a single trial.

Although it is clear that regressions computed from data from a few sites in one year cannot be used to assess the likely position in another year, there are good grounds for believing that the overall coefficients, which are based on results over four seasons from sites well distributed throughout the sprout-producing areas, can be used with fair confidence to determine probable losses, though with rather a large error, in any given year.

Insect damage can profitably be looked at as a product of pest density and the time the host plant remains infested. Therefore, it is not strictly appropriate to forecast yield reduction from an estimate of aphid density made at only one time during the growing season. A better estimate of the position can be obtained if forecasts are made on the basis of several pest counts made at different times in the season. A multiple regression analysis has therefore been computed with the present data so that due weight can be given to both early and seasonal peak aphid populations. The partial regression equation, in which yield (Y) is expressed as cwt of marketable sprouts per acre, and E and S denote early and seasonal peak aphid densities respectively, takes the form :

$$Y = 75{\cdot}1 - 3{\cdot}9\,E - 4{\cdot}7\,S$$

From this equation it appears that unit aphid values (Log (N + 1) : 1·00 aphids per three-leaf sample, or, detransformed, nine aphids per sample) decrease yield by about 3·9 and 4·7 cwt per acre early and late in the season respectively. The coefficients both differ significantly from zero, but not from each other.

The equation can be used to estimate the aphid levels which will be worth the cost of chemical treatment early and late in the season. Systemic insecticides vary in efficiency, but the best are effective for from a month to six weeks under field conditions, and the average cost of application to maturing Brussels sprouts is about £5 per acre. Over the last 10 years, sprouts have been worth approximately 42*s.* 6*d.* per cwt to the grower, so yields must be increased by at least 2·3 cwt per acre if the cost of a single application is to be recovered, and by twice this amount if two applications are made.

Cabbage Aphid Damage

Here it must be emphasized that little information is available on the long-term effects of a single spray application early in the season. If a very low initial aphid density is controlled as completely as possible, the young host plants will be able to make good growth, probably until quite late in the season, before an appreciable number of aphids build up on them. From the available results it seems likely that a density of 0·45 per sample is, on average, just worth controlling in July.

If a cost : benefit ratio of 1 : 2 is required, a July density of 1·00 aphids per sample will have to be controlled with a persistent insecticide rather more efficiently than is generally the case at present. An alternative would be to apply a second spray at the end of August. If an early spray is not applied, and the average July density is found to be about 0·86 (Table 1), a single spray at the end of August or early in September will repay its cost if the aphid density controlled is at least 1·12 per sample, and effective control of 0·45 aphids in July and at least 1·34 at the end of August will give a cost : benefit ratio of 1 : 1·4 for the two sprays.

Before discussing national losses, it must be stressed that the Log (N +1) aphid density values given above are the logarithms of the mean numbers of aphids per three-leaf sample based on at least 16 samples per plot of 100 plants. As such, a value of 0·85 may indicate a uniform infestation of six aphids per sample, or an infestation in which 15 samples are clean and the sixteenth contains a colony of 96 aphids on a single leaf. These extremes are infrequently seen in the field. For example, when 80 samples were examined individually in July 1952 and July 1953, 45 were clean, 17 were infested with less than 5 aphids, and 8 were infested with more than 20 aphids, the average Log value being 0·85. At this time of the year, roughly one-half of the samples will be uninfested. Although some accuracy is lost by bulking samples compared with individual examination, a great deal of time is saved.

Extensive Survey of Peak Aphid Density

An Extensive Survey of peak Cabbage aphid populations on unsprayed commercial sprout fields in England and Wales was started in the autumn of 1946 and has been carried out every year since. Empson (1952) has discussed the methods used, and summarized the first five years' results. The main point which remains to be discussed concerns the interpretation of the ranked survey results in relation to the information on aphid density and yield obtained in the field plot trials.

Table 4

Numerical Values Associated with Survey Rank Classes

Year	Plants Visually Classified as : Clean		Slightly Infested		Moderately Infested		Severely Infested	
	No. Plants Examined	Mean Aphids	No. Plants Examined	Mean Aphids	No. Plants Examined	Mean Aphids	No. Plants Examined	Mean Aphids
1953 ..	356	6	249	141	148	917	78	1,317
1954 ..	312	2	308	66	39	198	26	1,565
1955 ..	200	9	634	103	447	384	223	1,601
Three years }	868	5	1,191	101	634	497	327	1,531

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Before the survey results could be expressed in terms of actual loss in yield, the numerical aphid values appropriate to plants visually classified as " clean ", " slightly ", " moderately ", and " severely " infested had to be determined approximately. Collaborators in the survey were therefore asked to take three-leaf samples from as many plants as possible after making their visual assessments. These samples were taken back to the laboratory, washed, and the aphids counted. In the three seasons 1953, 1954, and 1955, over 3,000 plants were classified and then sampled in this way, and the results are shown in Table 4.

There was some variation in the numbers of aphids in each class from year to year, this being most marked in 1954, when the abnormally low density everywhere probably led to unconscious over-ranking—clean plants being ranked as slightly infested, and so on. To check the consistency of the surveyors, and to assess possible observer differences, twelve entomologists, from all co-operating provinces, met in the field early in September 1955. They were first asked to classify, according to definition, 100 sprout plants which had been previously labelled. Their field record sheets were then collected and examined, and the plants which had been given different ranks by different observers were looked at again by all those present, discussed, and a correct placement agreed. At the end of the day, paired three-leaf samples were taken from each of the 100 plants, and an average number of aphids per sample calculated for each of them. On the basis of the discussions and quantitative results, the ranking classes were re-defined before the 1955 survey was carried out. The new definitions were agreed as :

" *Clean* ". No colonies visible on outer leaves or sprouts, and only a few scattered aphids, not exceeding five or six, in a random sample of one top, one middle, and one lower, leaf.

" *Slight* ". One or more colonies on outer leaves or on the top, not more than $\frac{1}{2}$ inch in diameter, with not more than one colony exceeding 1 inch in diameter. Not more than about 200 aphids in a random three-leaf sample.

" *Moderate* ". Many individual colonies on leaves and/or top, often exceeding 1 inch in diameter, with not more than three leaves with colonies exceeding $2\frac{1}{2}$–3 inches in diameter. Up to about 750 aphids in a random three-leaf sample. Some plants may have been affected by aphids early in the season, yet be virtually clean in the middle of September. Such plants to be classified as moderately infested if at least five leaves show severe distortion due to aphid feeding.

" *Severe* ". At least half the leaves with large aphid colonies, mostly exceeding 3 inches in diameter or, in the absence of live aphids, covered with aphid detritus, parasite mummies, etc., and showing marked signs of severe distortion. More than about 750 and, in practice, an average of at least 1,500 aphids in a random three-leaf sample.

The modified definitions do not seem to have greatly altered the numerical values assigned to the four ranks. The three-year average excluding the 1955 survey samples is : clean : 5 ; slight : 101 ; moderate : 471 ; and severe : 969. The low severe value reflects the relatively small numbers of aphids from a declining population on 174 plants assigned to this rank by the field day observers in September 1955. The modified definitions have, in fact, raised the severe value up to a slightly higher level than the average for 1953 and 1954.

Apart from discussing and modifying the rank definitions, the twelve observers provided data for an analysis of observer differences. These are summarized in Table 5, and suggest that individuals apparently had no difficulty in consistently classifying plants which were clean or severely infested, but that there were real differences in their separate abilities consistently to classify slightly and moderately infested plants. The re-defined ranks should largely eliminate this inconsistency.

TABLE 5

ANALYSIS OF OBSERVER DIFFERENCES IN RANK SAMPLING

Plants Ranked	Average No. of Plants Ranked, and Range by Each Person	Mean Log (N + 1) Aphids per Three-leaf Sample	Between Observers		Within Observers		Variance Ratio
			Degrees of Freedom	Mean Square	Degrees of Freedom	Mean Square	
Clean ..	16 (14–21)	0·76	4	0·212	73	0·291	N.S.
Slight ..	44 (29–59)	1·50	11	1·402	519	0·505	2·78
Moderate	30 (15–45)	2·22	11	0·950	351	0·346	2·75
Severe ..	19 (12–30)	2·69	7	0·252	146	0·184	N.S.

From these data it is clear that there are quite large errors associated with the conversion of ranked results to quantitative terms. The standard error per plant, estimated from the pooled variances shown in Table 5, is $\pm$ 0·58 on an overall mean of 1·79, or 32·4 per cent.

The results given in Table 5 refer only to the samples taken by twelve observers in September 1955. Other data are available for plants which were ranked and then individually sampled, separate counts being submitted for 2,183 of the 3,020 plants analysed in Table 4. From these results it can be shown that the standard error per plant is nearer $\pm$ 0·33 on an overall mean of 1·46, or 22·6 per cent, than the 32·4 per cent quoted in the paragraph above. This error will be independent of the number of plants classified in each field sample, since it is really a bias due to the use of arbitrary weighting values. The standard errors attaching to the rounded off weighting values themselves (clean : 0·78 $\pm$ 0·06 ; slight : 2·00 $\pm$ 0·04 ; moderate : 2·70 $\pm$ 0·03 ; and severe : 3·18 $\pm$ 0·04) indicate the accuracy with which the mean population values have been estimated.

NATIONAL LOSSES DUE TO CABBAGE APHID, 1946–1955

Spray treatment of commercial Brussels sprout crops nearing maturity is a comparatively recent practice, and even with the introduction of systemic chemicals over the last few years it is doubtful whether more than about a quarter of the crops are treated. Most of these are sprayed in August, when aphids are often sufficiently abundant to attract the grower's attention. It has already been shown that treatment at this time does not eliminate the effects of aphid feeding over the previous three months, a fact which has to be taken into account in any attempt to assess national losses from peak survey data.

Whereas it has been possible to calculate a logarithmic index of seasonal peak aphid density for each of the years 1946–55 from the Extensive Survey results, no comparable data are available for early density peaks. In the absence of early results it has been assumed that the value 0·86 aphids per sample (Table 1), which is the average July value from the untreated field plots over a four-year period, provides a fair estimate of early peak density in any given year. The value of 0·86, associated in turn with the annual survey indices of seasonal peak density, enables the overall partial regression equation to be used to assess the probable loss in yield over 10 years in England and Wales. In this connection it should be noted that aphid density varies to a small extent in different parts of the country in any one year, being highest, generally, in the east and south-east (2·05 aphids per sample), and lowest in Wales (1·70 per sample), with a national mean of 1·89. Within years, however, the aphids tend to behave consistently throughout the country, so little importance attaches to the fact that fields were not always surveyed in the same counties from year to year.

TABLE 6

SURVEY RESULTS, SPROUT ACREAGES AND VALUES, AND YIELD LOSSES IN ENGLAND AND WALES

Year	No. of Unsprayed Fields Sampled	Index of Mean Log (N + 1) Aphids per Sample at Peak Density	Brussels Sprouts in England and Wales		Acreage Equivalents Lost Assuming Aphid not Controlled in August or September (*000 acres*)	Total Financial Loss Assuming No Spraying in the Late Summer (£'*000*)
			Annual Acreage (*000*)	Annual Value (£*m.*)		
1946	39	1·54 ± 0·338	45·5	6·34	6·4 ± 2·5	853·4 ± 342·3
1947	91	2·08 ± 0·332	50·3	5·63	8·7 ± 2·7	980·2 ± 298·5
1948	75	1·79 ± 0·333	54·0	4·76	8·5 ± 2·9	747·4 ± 257·0
1949	106	2·24 ± 0·332	42·6	3·99	7·9 ± 2·2	739·1 ± 207·7
1950	103	1·75 ± 0·332	44·6	5·17	6·9 ± 2·4	796·1 ± 279·1
1951	135	1·68 ± 0·331	38·0	5·45	5·7 ± 2·1	811·9 ± 294·2
1952	144	2·05 ± 0·331	44·3	5·91	7·7 ± 2·3	1,022·1 ± 313·1
1953	107	1·89 ± 0·332	51·5	4·34	8·4 ± 2·7	703·1 ± 230·0
1954	97	1·46 ± 0·332	42·9	5·43	5·8 ± 2·3	748·4 ± 293·2
1955	116	2·14 ± 0·331	46·2	6·22	8·2 ± 2·4	1,107·4 ± 329·7
Means	101	1·89 ± 0·328	46·0	5·32	7·5 ± 2·4	868·0 ± 282·2

The full results for ten years are set out in Table 6. On average, the Cabbage aphid costs the country rather less than £1 million per annum through damage to the sprout crop, but this is far from saying that it is not responsible for considerably greater losses, both as a virus vector and as a pest of other cultivated brassicae.

TABLE 7

LOSSES IN SPITE OF, AND GAIN FROM, CHEMICAL CONTROL IN THE LATE SUMMER

Year	Acreage Equivalents (*000*)		Financial Statement (£'*000*)		
	Lost Assuming Spraying in August/September whenever Necessary	Gain from Autumnal Spraying	Lost Assuming Spraying in August/September whenever Necessary	Gain from Sprays	
				Part Fields	Whole Fields
1946 ..	3·6	2·8	502·4	351·0	164·4
1947 ..	4·6	4·1	547·2	433·0	206·6
1948 ..	4·7	3·8	437·7	309·7	69·4
1949 ..	4·2	3·7	416·6	322·5	111·6
1950 ..	3·8	3·1	458·4	337·7	130·3
1951 ..	3·2	2·5	473·7	338·2	172·9
1952 ..	4·2	3·5	570·1	452·0	237·1
1953 ..	4·6	3·8	409·1	294·0	62·2
1954 ..	3·3	2·5	434·6	303·8	146·5
1955 ..	4·4	3·8	619·5	487·9	261·5
Means ..	4·1	3·4	497·4	370·6	161·3

It is therefore pertinent to assess the probable benefit to be derived from insecticide treatment. This has been done on the assumption that little or no such spraying is as yet carried out commercially early in the season. It has also been assumed that commercial spraying will give as good a control as was obtained with high concentrations of systemic materials in the field plot trials. From evidence obtained in the 1955 survey, this is doubtful. In this year, 116 untreated fields were surveyed and the average aphid density was assessed at 2·14 per sample, and 17 fields which had been commercially treated with organophosphorus compounds, mostly in August, had an average aphid density of 1·81 per sample, instead of 0·81 expected from the figure on page 3. Thus Table 7 gives

estimates of the maximum probable benefits which would have accrued had one efficient spray been applied in the late summer, firstly to every sprout plant which justified treatment, and, secondly, (and more practicably) to every field which would have justified expenditure on chemical control. A peak density of 1·00 aphids per sample has been taken as the limit below which treatment in August or September would have been uneconomic.

Acreage equivalents imply that proportion of the total sprout acreage which was essentially lost through Cabbage aphid attack—for example, a 10-acre field may yield 37·5 tons of sprouts in the absence of aphids, and only 33·2 tons if aphid density averages a log value of 1·00 per sample throughout the season. The yield of one acre has been lost through aphid attack, and the acreage equivalent is therefore one. The second and third columns of Table 7 summarize the national situation in these terms. The fourth column shows the estimated financial loss suffered through early and mid-season attack even if a spray had been applied whenever necessary in the late summer or autumn. The fifth column gives an estimate of the financial gain which would have accrued if fields had been subjected to " spot " treatment whenever necessary—that is, if only those areas of plants which were appreciably infested with aphids had been treated. The last column provides an estimate of the advantage gained from treating whole fields, even though patchy aphid distribution would have involved some waste of spray through application being made where not really necessary.

It is clear, from these results, that aphid control in August or September is often worth while, but that a greater general yield increase could be obtained by ensuring clean plants during the period of rapid growth that follows planting out in the field. Application of a systemic insecticide to plants in the seedbed a week or two before transplanting might give good control of the early migrant aphids which are responsible for initiating infestations in the field. The cost would be nominal compared with that of spraying the transplanted crop a month or six weeks after establishment.

The Conference of Advisory Entomologists would like to thank those farmers who allowed complex field trials to be carried out on a valuable crop. The writer would also like to thank Mr. H. W. Emery for providing official data on Brussels sprout acreages, yields, and cash values, and Mr. B. M. Church for advice on statistical procedure.

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PRICE INCREASE

It is regretted that owing to rising production costs, the price of *Plant Pathology* has had to be increased, as from this issue, to 5*s.* 0*d.* (5*s.* 2*d.* by post).

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CONTROL OF BULB FLY DAMAGE IN NARCISSUS

by H. C. WOODVILLE

National Agricultural Advisory Service, Starcross, Exeter

Experiments have been carried out for the past three seasons on bulbs grown for one year after being dipped in cold 0·2 per cent aldrin or dieldrin. The results of the first two years (Woodville, *Plant Pathology*, 1955, **4**, 83–4, and 1956, **5**, 73–4) showed that protection against damage by this method is extremely good. The results in 1955–56 confirmed these findings. The variety Magnificence showed 42 per cent of the control bulbs attacked by the larvae of *Merodon equestris* F., with no damage on bulbs dipped in either aldrin or dieldrin ; the variety King Alfred showed 55 per cent attack on the controls and none on the aldrin-dipped bulbs.

In 1954, the varieties Carlton, King Alfred and Fortune were dipped for 15 minutes in cold aldrin or dieldrin (both at 0·2 per cent actual chemical) and planted at Ellbridge Experimental Station, where they remained down for two years. A similar trial was carried out at Yelverton in Devon. Flower picks were recorded for both seasons, and, on lifting, the weights of the bulbs and the amount of Bulb fly attack were recorded. The flower picks in the first year were not significantly different between the treatments, but after one season's Bulb fly attack there was considerable difference, both in appearance and in flower pick, between the treated and the control plots. The control beds showed poorer foliage with many gaps, as compared with the beds containing dipped bulbs, which had no gaps and healthier looking leaves. The results were :

		Percentage of Bulbs With Fly		Clean	Flower Pick	Weight of Bulbs Total	Without Fly
		1955	*1956*			*kg*	*kg*
Ellbridge trials							
Carlton ..	..Control ..	34·0	41·0	25·0	116	14·65	3·55
	Aldrin ..	0·0	0·3	99·7	222	16·40	16·36
	Dieldrin ..	0·0	0·3	99·7	233	17·35	17·20
King Alfred	..Control ..	24·0	50·6	25·4	66	6·25	1·40
	Aldrin ..	0·0	3·0	97·0	119	9·33	9·30
	Dieldrin ..	0·0	1·1	98·9	130	10·61	10·60
Fortune ..	..Control ..	58·0	32·0	10·0	55	6·40	0·56
..	..Aldrin ..	0·0	1·5	98·5	232	16·15	15·85
	Dieldrin ..	0·0	1·8	98·2	206	14·35	14·10
*Yelverton trial**							
Golden Harvest ..	Control ..	16·4	30·7	52·9	—	—	—
	Aldrin ..	0·0	4·0	96·0	—	—	—
	Dieldrin ..	0·0	2·0	98·0	—	—	—

* Data kindly supplied by Mr. P. G. Allen, Assistant Horticultural Officer, Devon.

The table shows that the protection afforded by the treatments during the first year was complete, and that the amount of damage during the second year was small—judged by local standards it was negligible. The dipped bulbs appeared to be a better sample than the undipped, and this was also noted on a commercial holding where dipping had been practised for several seasons.

Two other materials, chlordane at 0·5 per cent, and heptachlor at 0·12 per cent, were also used for a 15-minute cold dip. The variety King Alfred was

used, and the amount of attack on two plots of control bulbs was 50·5 and 60·0 per cent. The heptachlor prevented all attacks, and on the chlordane plots the attack was 1·2 and 2·5 per cent respectively. Some advance in flowering date was noted with the chlordane treatment. In practice, there is no significant difference between the protection given by aldrin, dieldrin and chlordane, but the aldrin was the cheapest, dieldrin being two, and chlordane three times the cost of aldrin.

CONTROL BY ADDING INSECTICIDES TO THE HOT-WATER BATH

Following American work (Doucette, C. F., 1955, *in lit.*), experiments were carried out using heptachlor at 0·005 per cent, and chlordane at 0·0225 per cent in the standard hot-water bath. The variety used was Carlton, which was treated on September 1, 1955, for three hours at 110°F. After treatment, the bulbs were sub-divided, one lot being retained at Starcross for observation of any phytotoxic symptoms, and the other planted at Ellbridge, where a high incidence of Bulb fly could be relied on. Care was taken that the treatments were done while the bulbs were in their dormant period because, if root development had started, it is fairly safe to say that the materials would have damaged the roots, causing poor growth in the following season. The weights of bulbs lifted, and the numbers of flowers picked, showed that neither of the treatments had any adverse effect on the bulbs. Since the bulbs were lifted earlier than those from the other experiments, the degree of attack was lower, that on the two controls being 14 and 21 per cent. The bulbs treated with heptachlor showed 3·8 and 2·7 per cent attack, and those treated with chlordane 3·7 and 4·7 per cent. Some advance of flowering was noted with the chlordane-treated bulbs at Starcross.

One commercial sample of 16 cwt of the variety Sulphur was treated at Kea in Cornwall. Two batches of 8 cwt were treated in a commercial bath using heptachlor at 0·005 per cent. Observations made during the growing season showed no signs of damage or of retardation of growth, and the grower said that the flower pick was satisfactory. Treatment had been carried out on August 20, 1955, and sample bulbs were lifted on July 3, 1956. Two hundred bulbs were lifted, and two only had been attacked by the larva of Bulb fly. Unfortunately, all other bulbs on the holding had been cold dipped so that there were no untreated bulbs as a check, but Bulb fly had always been a serious pest on this holding.

APPLICATION OF THE METHOD IN PRACTICE

The cold dip in aldrin or dieldrin does present a practical method which can be used to stop the very serious commercial losses that occur in the bulb fields of the South-West. The actual dipping does not present any serious problems. A point which does cause some extra work is the use of containers for handling the bulbs. For the usual hot-water bath treatment, the bulbs are placed in crates of wood and wire mesh. If these are used for the cold dip, the wood will absorb some of the insecticide, and if subsequently used in the hot-water bath, the chemical will tend to leach out. In transferring liquid at a strength of 0·2 per cent in this way, it would be fairly easy to build the concentration in the bath up to a dangerous level. It has been found from preliminary experiments that the strength of dieldrin which is safe for use in the hot-water bath is 0·005 per cent. Therefore, to be quite sure that no damage would be caused to the bulbs, it has been necessary either to use all metal crates, or to re-crate all bulbs between the hot-water bath and the cold dip. The time taken for the

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re-crating is not important, as it is essential to allow the bulbs to cool before dipping. A period of twenty-four hours has been suggested, but observations made on commercial crates suggest that eight hours is sufficient for the centre bulbs to cool down to the air temperature. Although the cold dipping does involve some extra labour, many growers consider it worth while as it considerably reduces their financial loss due to Bulb fly.

The addition of heptachlor or chlordane to the hot-water bath offers a very promising method, since it does not involve any extra labour at a time when all the manpower is fully occupied; but the danger of root damage by these materials, once the roots have started to grow, does limit the time during which this method could be safely employed. On the larger holding, it is unlikely that many bulbs would be treated without danger of some root damage. On the other hand, the amount of Bulb fly damage found on the hot-treated bulbs is very low by present standards. The value of the protection given in the second year by this method is not yet known, but the cold dip does give protection in the second year.

Thanks are due to Mr. H. G. Morgan, of the Entomology Department, Starcross, for his help; to the staff of the Ellbridge Experimental Station; to the Horticultural Advisory Officers, and to the growers, particularly Mr. Eric Shone of Kea, who have permitted trials and observations to be made on their holdings.

CEREAL YELLOW DWARF VIRUS IN GREAT BRITAIN

by MARION A. WATSON AND T. MULLIGAN

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Cereal yellow dwarf virus, which damages cereal crops in the U.S.A. and Canada, was first described from California by Oswald and Houston (1951). Oswald informed us in 1954 that he had identified the virus in the Netherlands and he suggested that it was also present in Great Britain.

Samples of barley with many yellowed leaves and retarded ear emergence were collected on the Rothamsted farm in the summer of 1954. Aphids, later identified by Dr. D. Hille Ris Lambers as *Metapolophium dirhodum* (Walker) and *Sitobium fragariae* (Walker), were collected from crops of wheat and barley. They were fed for several days on the yellowed barley before being transferred to barley seedlings raised in the glasshouse. The test plants became yellowed, but so also did plants colonized by aphids which had not been fed experimentally on the yellowed barley. It therefore seemed that the effect might be due simply to aphid feeding, especially as the symptoms appeared less virulent than those described by Oswald and Houston, but later it was found that many aphids brought from the field were carrying the virus, which persisted in the vectors for many days.

The first clear evidence that the cause of the yellowing was a virus came from transmissions using a culture of *Myzus circumflexus* (Buckt.) maintained in the glasshouse on *Vicia faba*, and so free from the cereal virus. Plants on which *M. circumflexus* from beans had fed did not go yellow. They were larger, and

matured quicker than those colonized by *M. circumflexus* from the yellowed barley (Plate II, 2). Later, at Dr. Hille Ris Lambers' suggestion, a culture of *Rhopalosiphum padi* (L.), the " plum-grain aphid ", was started, and after a few transfers using this vector, severer and more easily recognized symptoms developed. Whether *M. dirhodum* and *S. fragariae* would have continued to transmit the less virulent disease from the same source, as suggested by the work of Toko and Bruehl (1956), was not tested.

The cereal aphids named by Oswald and Houston as vectors of the virus were *Rhopalosiphum* (*Aphis*) *maidis* (Fitch), the " corn aphid " ; *Rhopalosiphum prunifolii* (Fitch), the " apple-grain " (?) aphid ; *Macrosiphum granarium* (Kirby), the " grain " aphid ; *Macrosiphum dirhodum* (Walker), the " grass " aphid ; and *Toxoptera graminum*, the " green bug " which does not occur in Great Britain. Of the aphids tested by us, only *Metapolophium dirhodum* (Walker), which is the European name for *Macrosiphum dirhodum*, is clearly the same as those used in America. *R. padi* was used by Oswald in the Netherlands.

When fed on the infected plants for 48 hours and then on the test seedlings for 48 hours, *Rhopalosiphum padi*, used at the rate of 5 aphids per seedling, transmitted the virus to nearly all the seedlings tested. The symptoms took 15 to 20 days to develop in the glasshouse. The barley was stunted, ear emergence was delayed, and some or all of the leaves that developed after infection became golden or orange-yellow. More recent experiments on other cereals show that oat leaves become brownish-orange to bright crimson, and wheat leaves pale to golden yellow, or orange-red, depending on the variety.

The amount of discoloration and dwarfing depends upon the age of the plant at the time of infection, the time of observation, and, probably, on the strain or isolate of virus used. Recent observations suggest that varieties of wheat, oats and barley differ in their resistance to infection, symptom expression and to injury caused by the virus. " Blasting " of the florets, described by Oswald and Houston, has been observed in some varieties of wheat and oats under experimental field conditions.

Oswald and Houston and other North American workers have emphasized the damage done by this virus in commercial crops. In Great Britain the damage has not yet been assessed. So far, we have sampled crops with only a small proportion of infected plants. The virus seems to be widely distributed. We have isolated it from spring barley at Rothamsted and winter oats in Cambridgeshire, and it has been isolated by Dr. J. T. Slykhuis from plants of timothy grass, *Phleum pratense* (L.), from Aberystwyth, Wales, and perennial rye grass, *Lolium perenne*, at Rothamsted. The presence of the virus in perennial grasses is of particular interest, as they provide an overwintering host.

A small field experiment was made in 1955 on Plumage Archer barley. It consisted of three blocks of two plots. Each plot contained four sub-plots of 3 rows of barley 33 inches long, isolated in a much larger area of the crop. Three of the sub-plots, (Nos. 2, 3, and 4), on each plot had muslin cages placed over them ; No. 1 had no treatment but was a control to measure the possible effect of shading by the cages. Of the three caged sub-plots, No. 2 did not receive aphids; No. 3 was infested with aphids which had fed for one week on barley plants that were known to be infected with cereal yellow dwarf virus ; No. 4 was cultured with aphids from the stock cultures, which were presumed to be healthy but were later found to have been infected, so that these two plots were really replications of the same treatment.

About 1,000 *R. padi* were introduced into each of cages 3 and 4 and allowed to feed for one week. All the caged plots, including those which did not receive

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aphids, were then sprayed with nicotine, and the cages removed. One plot in each block had the infected aphids feeding on it from April 25 to May 2 and the other from May 3 to May 10, so that the mean dates for early and late infection were only one week apart.

During the second week of June the early-infected plants had several brightly chlorotic leaves and the tips of the upper leaves of the late-infected ones were already changing colour. In July, the early-infected plots were stunted ; their characteristic colour was no longer visible from outside the area of the experiment, because the healthy plants were taller. However, at harvest there seemed to be little difference in the height of the infected and control plots. The yields of air-dry grain and straw, harvested on 12 August, are given in the table.

EFFECT OF INFECTION WITH CEREAL YELLOW DWARF VIRUS ON YIELD OF GRAIN AND STRAW

Treatment	Yield of Plumage Archer Barley (grammes per plot)			
	Grain		Straw	
	Early Infection	Late Infection	Early Infection	Late Infection
1. Control, not caged	164	153	199	187
2. Caged, without aphids	146	153	215	190
3. Caged, with aphids fed on infected barley	106	120	189	200
4. Caged, with infected aphids from stock culture	89	129	183	193
S.E*	± 8·5		± 17·5	
Healthy (mean of 1 and 2)†	155	153	207	189
Infected (mean of 3 and 4)	98	124	186	196
S.E*	± 6·0		± 12·4	
Percentage loss of yield due to infection	37 ± 5·5	19 ± 5·6	10 ± 8·4	−4 ± 9·2

* Appropriate for cross comparisons, with early or late infections.

† Early- and late-infection treatments were applied in different blocks, and the means for treatments 1 and 2 refer to the same blocks as the early or late infections.

There was no difference in appearance, and no significant differences in yield, between the healthy sub-plots which were shaded for one week during the infection period and those which were not, nor between the two sources of infection. There was a considerable difference in grain yield between the effects of infection at the early and late dates, although these were only about eight days apart : plants infected on April 25 lost nearly 40 per cent of their grain yield and those infected a week later only about 20 per cent. Presumably the plants infected earlier were at the critical stage just before tillering, as described by Oswald and Houston (1953).

The yield of straw was scarcely affected by the virus infection, although reduction in height had been obvious at the earlier observation times The yellowing symptoms became less obvious when the barley started to ripen, and had the infected plants not been concentrated in a small area they would have been difficult to distinguish. In ordinary field conditions the infected plants are probably scattered among the healthy ones, and so cereal yellows may cause some loss of yield without its presence being noticed.

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CHRYSANTHEMUM FLOWER DISTORTION DISEASE IN SOUTH-EAST SCOTLAND

by D. C. GRAHAM*

East of Scotland College of Agriculture, Edinburgh

During the seasons 1952–54, opportunity was taken to examine many thousands of chrysanthemums, and a large number were tested for virus infection. The symptoms observed were, in general, similar to those already described (Bewley and Richards, 1951 ; Hollings, 1955). Among the isolations made by the writer, three strains of aspermy virus and Noordam's b virus were detected. On two occasions cucumber mosaic virus was isolated, but tomato spotted wilt was never encountered. Virus b was most frequently obtained from the varieties Annie Curry, Ruby, Imperial Yellow, George McLeod, Red Flare, Viewbank Crimson and Herbert Sutcliffe. These varieties had distinct leaf mottles.

Leaf mottles of various kinds are found on chrysanthemums, by no means all of which can be attributed to virus infection. Vein clearing, presumably of genetical origin, was common on Balcombe Perfection and its sports, Sweetheart, and on Golden Marvel. The symptoms were not transmissible to Shirley Late Red by grafting.

SURVEYS IN 1953 AND 1954

Until the present surveys were carried out, nothing was known about the extent of this disease in Scotland. A survey of the disease in England took place during the late-flowering period 1951–52 (Prentice, 1952), the main conclusions of which were that although the disease was widespread, it was well under control.

The surveys considered here include both early-flowering and late-flowering varieties. Observations were made during the periods September–December, 1953 and 1954. A total of twenty-three nurseries were visited in East, Mid-, and West Lothian, Perth and Angus. Symptoms were noted and counts made of diseased and healthy plants. Unfortunately, results obtained in 1954 were not so useful as those of 1953 owing to the bad weather conditions during the growing season. Therefore, most of the figures mentioned below refer to 1953, although the position in 1954 was generally similar. In each year, samples of various types of symptom expression were taken and isolations made from these to check the accuracy of the field diagnosis. Tests were made for sap transmissible viruses only, by inoculating White Burley tobacco, and a strain of *Petunia hybrida nana* which is especially sensitive to virus b.

The results of the survey indicate that the disease had become extensively distributed throughout chrysanthemum stocks, more especially in the early-flowering varieties. Indeed, only 33·3 per cent of the early-flowering stocks examined in 1953 and 31·1 per cent of those examined in 1954 were entirely free from virus symptoms. In late varieties, however, 75·9 per cent in 1953 and 80·3 per cent in 1954 were apparently healthy. The discrepancy between the amount of infection in earlies and lates is very difficult to explain, since the conditions of cultivation are virtually the same for both and, indeed, exposure

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to aphid-borne infection is probably greater in the case of late varieties. A possible explanation is that more attention to such matters as spraying and roguing is given to the more remunerative late-flowering types. Of totally infected stocks of early-flowering varieties, 14·7 per cent were found in 1953 and 15·1 per cent in 1954. The corresponding figures for late-flowering stocks were 9·1 per cent and 8·7 per cent. In general, these stocks could be divided into two groups : namely, those recently imported from other nurseries, the stock having been rapidly built up (for example, Bravado) ; and old varieties, which had been grown on the nursery for many years (for example, Utopia, Ada Brooker).

TABLE 1

NUMBER OF CHRYSANTHEMUM STOCKS EXAMINED IN 1953, GROUPED ACCORDING TO DIFFERENT INFECTION LEVELS

Infection Level %	0	0·1–24	25–49	50–74	75–100	Total No. Examined
Earlies	68	75	22	9	30	204
Lates	126	12	6	6	16	166

When each of the stocks of varieties is grouped according to percentages of infection, the result given in Table 1 is obtained, from which it can be seen that the highest incidence of infection in the earlies occurs in the " low " infection group, 0·1–24 per cent. The incidence then falls steeply to a low figure in the 50–74 per cent group and rises again to a fairly high value in the " high " infection group, 75–100 per cent. A similar, though less marked, trend occurs with the late-flowering kinds. It is thought that these variations reflect the methods whereby diseased stocks are obtained. Increase of the disease may take place firstly by aphid transmission and secondly by the propagation of small, newly-infected stocks. Since it is unlikely that aphids would infect the greater part of a stock at any one time, unless the stock happened to be a very small one, aphid transmission may be reflected principally in the first group, 0·1–24 per cent. Disease incidence due to propagation and age of stock is probably reflected in high infection group, 75–100 per cent. In old stocks, exposure to aphid-borne infection and propagation of diseased material has usually occurred over a period of many years, and in most of the older varieties there is a very high incidence of infection. However, the age of the stock is not the only factor of importance, as examination of the dates of introduction showed certain old varieties to be free from disease. Varietal susceptibility may possibly play a part.

On those nurseries where horticultural practice was of a low standard, the incidence of the disease was very high. On the other hand, where severe roguing and rigorous selection had been carried out, the amount of disease was correspondingly low. Figures comparing two such nurseries are given in Table 2.

TABLE 2

COMPARISON OF DISEASE INCIDENCE ON NURSERIES WHERE NO ROGUING AND RIGOROUS ROGUING HAD BEEN CARRIED OUT FOR SEVERAL YEARS

Nursery	Type of Chrysanthemum	Total Number of Plants	Number Infected	Percentage Infected
Not rogued	Early	12,759	1,977	15·5
	Late	5,150	721	14·0
Rogued	Early	3,688	98	2·7
	Late	3,060	138	4·5

One nursery visited in 1953 had an exceptionally large number of diseased plants, and roguing was carried out rigorously by the nurseryman. On revisiting

the nursery in 1954, it was obvious that although the disease was still widespread, the number of diseased plants had been considerably reduced. The figures, which are given in Table 3, refer to early-flowering varieties only.

TABLE 3

EFFECT OF ONE YEAR'S ROGUING ON DISEASE INCIDENCE

	Total Number of Plants	Number Infected	Percentage Infected
1953	1,944	603	31·0
1954	2,303	392	17·0

Care is needed when diagnosing the disease from symptoms alone, since other conditions may simulate virus distortion. One-sided and distorted blooms which were seen in the varieties Favourite and Fiona, were due to attacks by *Botrytis cinerea*. Cases of slight sodium chlorate damage were seen on one nursery, where the plants were stunted, the leaves mottled and the blooms distorted. Frost damage was prevalent amongst late-flowering varieties in 1954, and the damaged buds produced flowers which could easily be mistaken for virus-infected material. Insect damage to the buds caused by capsids, aphids and earwigs produced a similar effect, and hormone damage by the drift of 2, 4-D sprays on the varieties Sweetheart, Golden Seal, Lighthouse and Birmingham was similar, in many respects, to virus distortion. However, the flowers, although very severely distorted, did not lose colour value.

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PELARGONIUM RING SPOT

by M. HOLLINGS

Plant Pathology Laboratory, Harpenden, Herts

The ivy-leaved geranium, *Pelargonium peltatum* Ait., is commonly grown as a decorative pot plant, and also as a bedding plant in many municipal gardens and parks. This paper describes a condition believed to be a virus disease differing from any previously recorded on pelargoniums.

A number of *P. peltatum* plants from widely differing localities have been grown in an insect-proof glasshouse over the past four years, all being affected by a ring spot disease. Yellowish spots, rings and broken ring markings developed on the younger leaves in early spring, becoming more intense until about mid-July ; after this, the symptoms faded on the older leaves, and young leaves

to aphid-borne infection is probably greater in the case of late varieties. A possible explanation is that more attention to such matters as spraying and roguing is given to the more remunerative late-flowering types. Of totally infected stocks of early-flowering varieties, 14·7 per cent were found in 1953 and 15·1 per cent in 1954. The corresponding figures for late-flowering stocks were 9·1 per cent and 8·7 per cent. In general, these stocks could be divided into two groups: namely, those recently imported from other nurseries, the stock having been rapidly built up (for example, Bravado); and old varieties, which had been grown on the nursery for many years (for example, Utopia, Ada Brooker).

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A number of *P. peltatum* plants from widely differing localities have been grown in an insect-proof glasshouse over the past four years, all being affected by a ring spot disease. Yellowish spots, rings and broken ring markings developed on the younger leaves in early spring, becoming more intense until about mid-July ; after this, the symptoms faded on the older leaves, and young leaves

developed few or no markings during late summer and autumn. (Plate I, 1). Although symptoms were occasionally seen at all seasons of the year, in general, the plants were symptomless in autumn and winter. In experiments with several clonal lines of these plants, it was found that neither light intensity nor temperature directly influenced symptom expression, but that intensity of symptoms depended on rapidity of growth. Conditions which led to rapid plant growth also induced severe symptom expression.

All plants of *P. peltatum* which have been examined, in many localities, have shown ring spot symptoms in summer, so it is impossible to assess the effects of ring spot disease ; there is, however, no obvious lack of vigour, though on some flowers the petals are irregularly inserted and bear occasional curled enations (Plate I, 3).

Scions from *P. peltatum* plants showing ring spot symptoms were grafted in May 1953 to four cuttings each of nine *P. zonale* seedlings, using the inarch bottle graft method. After 10–12 months yellowish spots and rings developed on plants of two lines of the seedlings (Plate I, 2), and rather indefinite chlorotic spots on some leaves of the other lines. Uninfected control plants of all lines showed no such markings. The symptoms on the two clones faded during the summer, and did not re-appear until the following spring, just as in *P. peltatum*. None of the infected *P. zonale* plants showed any flower abnormalities. Similar grafts to the variety Paul Crampel of *P. zonale* showed indefinite leaf symptoms, or none.

No transmission was obtained (from *P. peltatum* to cuttings of the indicator seedlings of *P. zonale*) when adult apterous *Myzus persicae* Sulz. were allowed either short (2–5 minutes acquisition feed and 1 hour test feed), or long (3–5 days acquisition feed and up to 7 days test feed) feeding periods ; most aphids refused to feed for long on *P. zonale*. A yellow spot virus disease of pelargonium described in Austria (Wenzl, H., *Pflanzenarzt*, 1954, **7** (Special Issue), 11 pp.) differs in being aphid transmissible.

Mechanical inoculations, either by conventional methods or by Yarwood's rapid method, from *P. peltatum* to *P. zonale* indicator seedlings failed to infect. No reaction could be detected on any of the following plants after similar inoculations :

Alonsoa warscewiczii	*Lactuca sativa*	*Phaseolus vulgaris*
Amaranthus caudatus	*Lavatera trimestris*	*Physalis floridana*
Antirrhinus majus	*Nicandra physaloides*	*Tetragonia expansa*
Brassica pekinensis	*Nicotiana clevelandii*	*Vicia faba*
Chenopodium amaranticolor	*Nicotiana glutinosa*	*Vigna sinensis*
Cucumis sativus	*Nicotiana rustica*	*Zinnia elegans*
Gomphrena globosa	*Nicotiana tabacum*	

P. zonale plants infected with ring spot were later graft-infected with pelargonium leaf curl virus ; all developed semi-necrotic, yellow stellate spots on the younger leaves in the winter months. These symptoms were typical of leaf curl infection, and quite different from the chlorotic yellowish spots of ring spot infection, which occur in spring and summer. A further difference between ring spot and leaf curl was found in the ability of leaf curl to infect a large number of host plants by mechanical inoculation.

No pathogenic fungi could be isolated from plants affected with ring spot, and though the evidence is not conclusive that the disease is due to virus, its graft transmissibility and type of symptoms strongly suggest that this is so.

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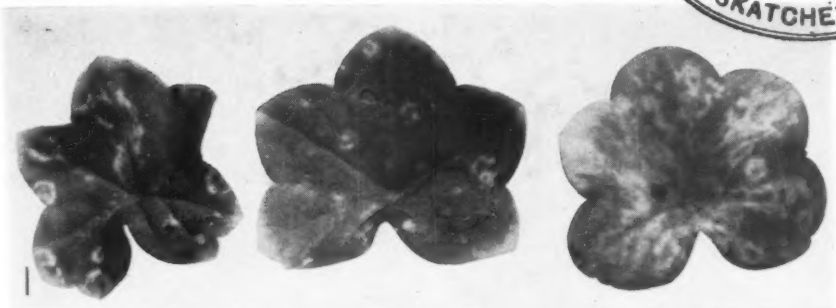
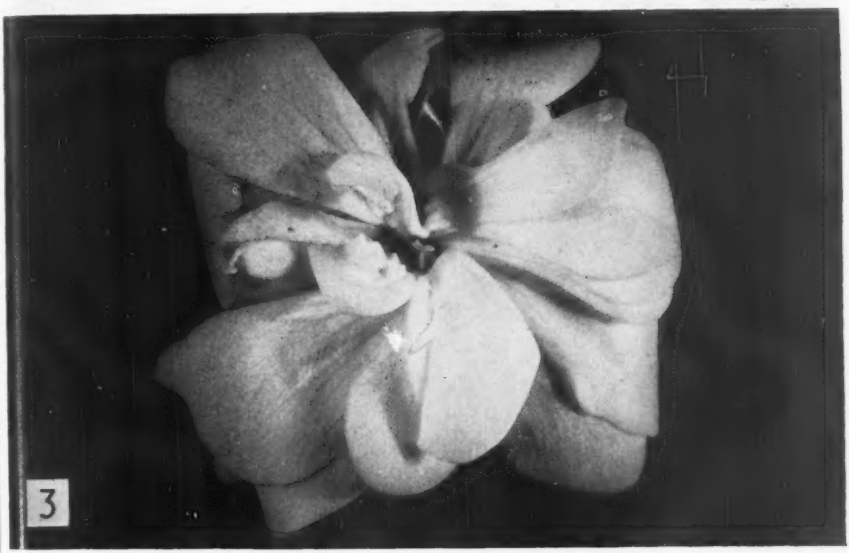




1. Symptoms on *Pelargonium peltatum*.
2. Chlorotic leaf marking on *P. zonale* after graft infection with ring spot.
3. Flower of infected *P. peltatum* showing petal distortions and enations.

PLATE I

68500)

CONTROL OF BACTERIAL CANKER WITH STREPTOMYCIN

(see pp. 31–5)

Photo: East Malling Research Station

1. *Left :* Cherry leaf sprayed with streptomycin. *Right :* Unsprayed control showing leaf spot infection.
Photograph by transmitted light. Glasshouse trial. *Variety :* Napoleon.

CEREAL YELLOW DWARF VIRUS (see pp. 12–4)

Photo: Rothamsted Experimental Station

2. Stunting of barley caused by the virus. The inner plants were cultured with *Myzus circumflexus* from yellowed barley, and the two outer with the same species from broad bean.

PLATE II

PSEUDOPLEA TRIFOLII ON LUCERNE (see p. 38)

1. Lucerne plants affected with Burn, showing numerous light brown lesions, with darker brown rims. Aberystwyth 1956.

APPARATUS FOR RECORDING RATE OF SPORE DISCHARGE (see pp. 25–6)

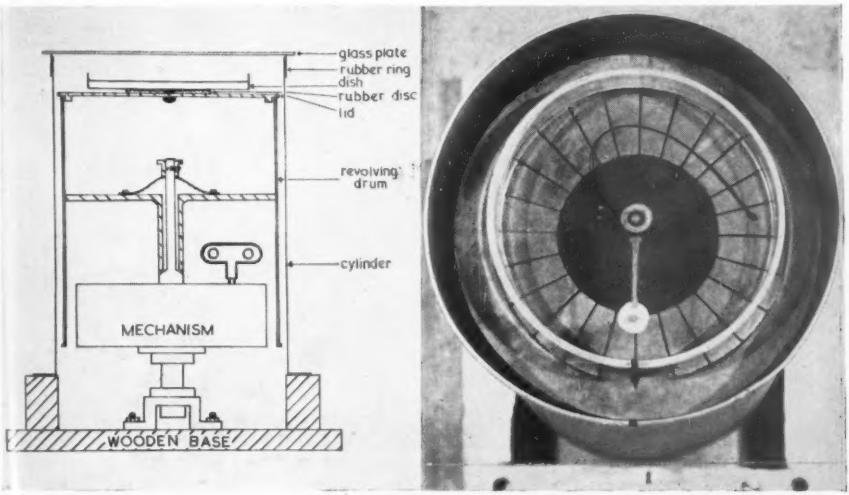
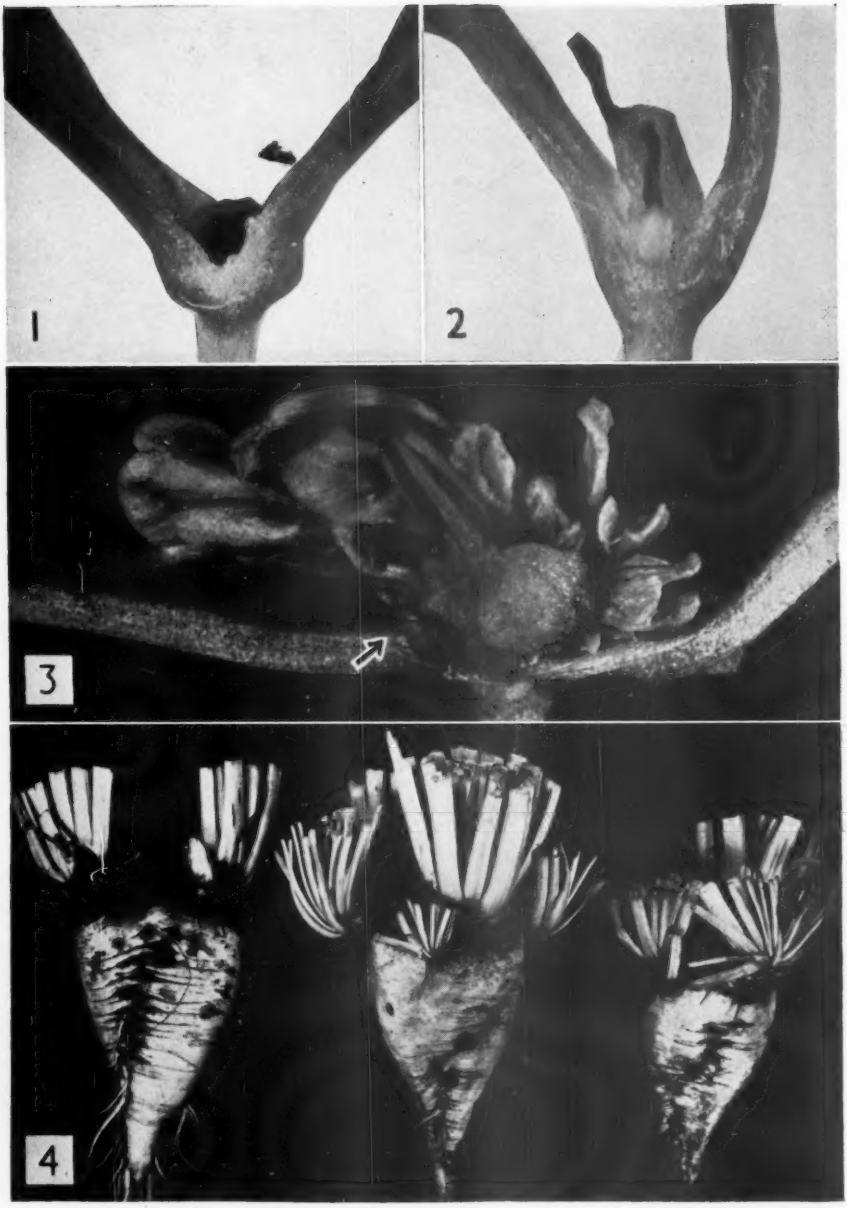


Photo: Long Ashton Research Station

2. *Left :* Diagrammatic vertical section of apparatus. *Right :* View from above when ready for use, with spore source represented by a white disc.

PLATE III



1. Necrotic growing point and 2, necrotic tips and swollen bases on first foliage leaves due to mirid attack.

3. Lateral bud development following death of growing point, with swollen petiole of original first foliage leaf and distortion of new growth. Arrow marks site of egg.

4. Multiple-crowned and stunted beet resulting from early mirid damage.

PLATE IV

MIRID DAMAGE TO SEEDLING BEET

by R. A. DUNNING

Sugar Beet Research and Education Committee Pests Investigations, School of Agriculture, Cambridge

Mirid damage to sugar beet during the summer is well known but is rarely of importance. Usually, it starts late in June alongside the hedgerow, the damage consisting of leaf petiole, lamina, and vein puncturing and scarring, commonly leading to tearing, distortion, puckering and leaf yellowing. Such injury is due to mirid nymphs migrating from woody winter hosts (Jones, F. G. W., Sugar Beet Pests, *Bull. Minist. Agric. Fish. Lond.*, No. 162, 1957).

Damage to seedling beet is not so common but it was particularly widespread in 1956, especially in the Worcestershire area. Beet attacked in the cotyledon and early seedling stages develops characteristic symptoms. Walton and Staniland (*Rep. agric. hort. Res. Sta. Bristol*, 1929, 99–100) described some o the symptoms found in Somerset in mid-June. Nymphs of *Lygus pabulinus* (L.) were responsible, and the attack was limited to a belt 30–40 yards wide alongside a hedge in the late-sown (May 13) part of a beet crop. The other part of the crop, sown on April 18, did not suffer in the same way. Multi-crowned plants, resulting from early injury by *Calocoris norvegicus* (Gmel.), and possibly also *L. pabulinus*, have been reported in Denmark by Bovien and Wagn (*Månedsovers. Plantesygd.*, 1951, No. 319, 70–1).

In 1956 a characteristic set of symptoms was noted, as a result of mirid attack, in samples of beet seedlings from various parts of England. All the crops were sown at the normal time, and the samples were examined between May 11 and June 9. In seedlings attacked before the first rough leaves had formed, the growing point was completely killed, leaving only rounded and slightly swollen stumps of necrotic tissue between the two cotyledons (Plate IV, 1). Where the first rough leaves had begun to form, these were reduced to swollen lumps of tissue with blackened tips, the growing point again being killed (Plate IV, 2). Damage after the first foliage leaves had unfolded was confined to severe temporary distortion of the heart leaves, often causing swelling of the leaf bases and necrosis of the leaf tips. At all stages feeding scars could often be found on the hypocotyl and cotyledons, but caused little obvious damage. In one instance where selective singling was not carried out, up to 50 per cent of the plants were " blind " in parts of the field.

When the growing point was killed, the cotyledons became much enlarged and thickened, and lateral buds developed. At first, such fresh growth was much distorted (Plate IV, 3) and highly coloured, and in late June, and July, the numerous foliage leaves were often strap like. Later in the summer, the foliage became quite normal, and the only evidence of attack late in the season was a root rather stunted as a result of the original setback, and with a multiple crown (Plate IV, 4).

Although the majority of the fields had overwintering sources of mirid eggs nearby, no evidence was obtained that any of these attacks were caused by migrating nymphs. As damage almost invariably occurred at random over the whole field, it seems likely that adults were responsible. Eggs of two mirid

species were found laid in the hypocotyl, cotyledons, or hearts of the plants (Plate IV, 3) between May 23 and June 15, when the first " hatched " egg was seen.

Hille Ris Lambers (*in lit.*) noted that blind seedlings occurred exceptionally in cases of very heavy mirid infestation near elm trees from which nymphs of *Calocoris norvegicus* had been blown. It seems unlikely that this explanation can apply to the widespread attacks that occurred in 1956, and the attack described by Walton and Staniland as due to migrant nymphs was much later in the year than the present ones.

I am indebted to Mr. S. G. Revel for the photographs.

CONTROL OF CHRYSANTHEMUM EELWORM BY PARATHION

by J. W. BRYDEN AND W. E. H. HODSON

National Agricultural Advisory Service, Reading

Before 1950, there was no chemical known which would effectively control Chrysanthemum eelworm, *Aphelenchoides ritzema-bosi* (Schwartz), except sodium selenate. This material was too dangerous to be of commercial use. Up to this time, the eelworm was controlled either by " cold-water treatment ", in which the pest was washed off the stools by a strong jet of cold water, or by " warm-water treatment ", in which the stools were immersed (after cleaning and trimming) in water at 110°F for 25 minutes, or 115°F for five minutes. Cold-water treatment was laborious and not completely effective. Warm-water treatment, although effective in its action on eelworms, was not considered safe by many growers. After-care of the treated stools was not fully understood and some damage to them was considered almost inevitable.

In 1950, one of the leading British insecticide manufacturers announced that 0·025 per cent parathion was a promising spray material for the control of Chrysanthemum eelworm. In 1951, the entomologists of the South Eastern Province investigated the treatment to provide information on the efficiency of control of the eelworm, and the minimum number of applications of parathion required for effective commercial control. The following is an account of studies carried out by the Reading staff only, but results of similar work carried out at Wye were made available and were freely used in planning further work in 1952 and 1953.

TRIALS ON EARLY (OUTDOOR) VARIETIES

In 1951, seven varieties on four nurseries were chosen for experimentation, but eelworm developed sufficiently in only two of these. One hundred cuttings of each variety were taken at random from the infested stools and struck in boxes. After rooting, the cuttings were transplanted twenty-four to a box. When established, the plants in two boxes of each variety were sprayed with 0·005 per cent parathion (4 fluid ounces of 20 per cent preparation per 100

gallons water). Two boxes of each variety remained untreated. A second application was given about one month later. The plants from all boxes were set out in four beds in open ground in late May.

Eelworm infestation reached a peak in early August, when a visual estimation of the degree of infestation was made. Leaf samples were removed to the laboratory for examination. None of the 39 Dorothy Speat and 40 Mary Mona sprayed plants was infested, but 29 untreated plants of the former variety showed visible symptoms out of 34 infested. Nine untreated Mary Mona plants also showed visible symptoms out of 11 subsequently found to be infested.

The results were clearly promising. A few nurseries were using parathion commercially in 1951 and observations made on these nurseries, together with information from Wye, suggested that parathion might be more effective if applied at an earlier stage of growth. It was decided to apply the spray in 1952 as soon as the cuttings were rooted and again one month later. Five varieties were used on two sites. A third spray was applied to four of these, about one month after the second application. One of these four varieties failed to develop eelworm symptoms and is omitted from the results in Table 1.

TABLE 1

EFFECT OF SPRAY TREATMENT WITH 0·005 PER CENT PARATHION ON OUTDOOR VARIETIES, 1952

Variety	No. of Plants per Treatment	1st Count 28.7.52 No. of Plants Infested		2nd Count 22.9.52 (when Crop in Bloom) No. of Plants Infested	
		Sprayed	*Control*	*Sprayed*	*Control*
Corona	14	1	12	1	14
Vanity	27	0	22	2	24
Susan Blades	22	4	22	4	22
Jean Walker	54 sprayed 48 control	4	31	10*	40

* Some cross infestation took place late in the season in the variety, Jean Walker, so that the control may have been more efficient than that suggested by the figures in the record.

These results were similar to those obtained in 1951 and indicated that a worthwhile reduction in eelworm infestation could be obtained in outdoor varieties by applying 0·005 per cent parathion twice, at monthly intervals, early in the lives of the plants. The third spray, applied in 1952 to three of the varieties, did not result in appreciably better control than that obtained by two applications only in 1951 and 1952. This, together with the complete failure of single late sprays—observed on several nurseries in 1951 and 1952—suggested that such late applications were not really effective.

TRIALS ON MID-SEASON AND LATE VARIETIES (INDOOR FLOWERING)

Six varieties (three mid-season and three late) on five nurseries were used in 1951. Two materials were applied : 0·005 per cent parathion, as for the early varieties, and 0·25 per cent schradan (3 pints of 66 per cent preparation per 100 gallons of water). The cuttings were taken and cultured as for the early varieties, except that some varieties were transplanted initially into 3-inch pots, instead of 24 per box. All varieties were finally potted in 9-inch or 10-inch pots and housed under glass for flowering. The sprays were applied to the plants after establishment in the 3-inch pots or boxes, and again from four to seven weeks later. Counts (Table 2), similar to those of the early varieties, were made in

August. Eelworm infestations declined in the three late varieties after housing, and a final count at flowering time was not possible.

TABLE 2

EFFECT OF SPRAY TREATMENTS ON MID-SEASON AND LATE VARIETIES, 1951

Treatment	Variety	No. of Plants per Treatment	Sprayed Plants		Control Plants	
			No. Infested	No. with Visible Symptoms	No. Infested	No. with Visible Symptoms
Parathion 0·005% ..	Edward Page*	15	0	0	9	9
	Golden Seal*	26	15	6	25	25
	Red Beauty†	16	14	7	16	12
	Capt. Kettle†	6	4	4	6	5
Schradan 0·25% ..	Magnet*	16	10	7	15	13
	Christmas Beauty†	6	2	2	6	3

* Mid-season Variety. † Late Variety.

With parathion, the control on the variety Edward Page was good. It was less satisfactory on Golden Seal, although better than the figures suggest, as the 6 sprayed plants showing symptoms were only slightly affected, whereas all 25 control plants were very severely " blotched ". Control was even less satisfactory on the two late varieties although, here again, the symptoms on the infested sprayed plants of Red Beauty were much less marked than on those on the untreated plants.

Schradan was not so effective as parathion, the infested sprayed plants of Magnet being very severely affected. A third spray applied in late August to half the sprayed stock of Magnet and Golden Seal had no visual effect in reducing the infestation. These results were rather disappointing. Of the two, parathion seemed a little more effective and was appreciably cheaper and safer in view of the very high concentration of schradan used.

In 1952, early sprays of parathion only were tested. Four varieties on two nurseries were used. The first spraying took place immediately after rooting and was repeated a month later. As in 1951, eelworm failed to continue development after the plants were housed in the autumn, and a December count was ruled out because of severe rust and mildew on three of the varieties. Table 3 gives the results obtained in a late September examination. The results were inconclusive, but the degree of control appeared to have been appreciably better than that obtained in 1951.

TABLE 3

EFFECT OF SPRAY TREATMENT WITH 0·005 PER CENT PARATHION ON MID-SEASON AND LATE VARIETIES, 1952

Variety	No. of Plants per Treatment	Count on 22.9.52 No. of Plants Infested	
		Sprayed	*Control*
White Favourite (Site 1)	38	0	34
Red Favourite	21	0	21
Pink Favourite	18	10	18
Sunstone	17	2	14
White Favourite (Site 2)	66	13	28

Control of Chrysanthemum Eelworm

A further experiment was planned for 1953 to study the use of a more concentrated spray, the effect of spraying the plants still earlier in their lives, and the effect of the time of rooting the plants on eelworm control. Two heavily infested stocks of Apricot Wallace and Amber Favourite on a nursery in south Hampshire were selected for this study. Parathion was used at two levels: "high concentration" (0·025 per cent); and "low concentration" (0·01 per cent on stools and 0·005 per cent for other applications). Seven treatment combinations were used: stool watering with low concentration parathion followed by low concentration sprays immediately after rooting and repeated one month later, "stools and sprays (low)"; the same combination using high concentrations, "stools and sprays (high)"; watering the unrooted cuttings at time of striking, followed by low concentration sprays, "cuttings and sprays (low)"; and the same using high concentration in all applications, "cuttings and sprays (high)". The fifth treatment combined low concentration applications to the stools, cuttings and rooted plants, "stools, cuttings and sprays (low)"; the sixth was the same but using high concentrations, "stools, cuttings and sprays (high)" and the last treatment was a "control" untreated.

On February 16, all green material was removed from the stools before stool watering with parathion. Half of the trimmed stools were left untreated to be used in the later treatments and as controls. The cuttings removed in trimming up the stools were used to provide a series of early-struck cuttings to compare with the main series, which were struck on March 20. All the plants were struck in boxes and then potted up in pairs in size 48 pots, being finally transferred to 12-inch pots. Three infestation counts were made during the season, the last being at the time of marketing. Plants were classified on visual symptoms as free, infested, or substantially affected. The last classification denoted plants which produced distorted blooms or exhibited leaf symptoms within nine inches of the blooms. Table 4 shows the results obtained in the final count.

Table 4

Effect of Parathion Treatments on Mid-season and Late Varieties, 1953

Treatment (for explanations see text)	No. of Pots Infested	
	Apricot Wallace	Amber Favourite
Early-struck series	20 Pots per Treatment	12 Pots per Treatment
Cuttings and sprays (low)	6 (2 S)*	12 (3 S)
Cuttings and sprays (high)	7 (1 S)	4 (1 S)
Untreated	20 (20 S)	12 (12 S)
Main series	15 Pots per Treatment	15 Pots per Treatment
Stools and sprays (low)	3	4 (3 S)
Cuttings and sprays (low)	1	2
Stools, cuttings and sprays (low) ..	2	2
Stools and sprays (high)	4	4
Cuttings and sprays (high)	3	2
Stools, cuttings and sprays (high) ..	2	2
Untreated (control)	10	14 (5 S)

* S = Substantially affected.

In the early-struck series, both spray strengths gave about the same degree of control, the stronger solution being rather better on Amber Favourite, although even here only three pots sprayed with the weaker material were substantially affected, compared with the full twelve in the untreated pots. In the main series, there was virtually no difference between the treatment combinations

using low concentration solutions and those in which 0·025 per cent parathion was used, except for the " stool and sprays (low) " treatment on Amber Favourite. Taking the two series together, it would appear that the spray strength was immaterial between the limits of 0·005 and 0·025 per cent.

All treatments, except the control, involved two post-rooting sprays. In two treatment combinations both stools and unrooted cuttings were watered with parathion, " stools, cuttings and sprays " ; in two others, stools only were watered, " stools and sprays " ; and in a further pair, cuttings only, " cuttings and sprays ". The control was appreciably poorer in the " stools and sprays " combinations, indicating that stool treatment alone is inferior. There appears to be little difference between the other four combinations, so that stool treatment does not enhance the efficiency of the unrooted cutting treatment, which appears to be the most effective.

Comparing the controls (untreated) in the early-struck series with those in the main series, it is seen that the former pots were all substantially affected, whereas, in the latter, only 10 pots out of 15 Apricot Wallace were infested, and of these none was in the " substantially affected " class The main series of Amber Favourite were almost all infested, but only five were placed in the " substantially affected " class. Both series came into bloom at the same time. This may give a clue to the difficulty found in controlling eelworm with parathion in the slower late varieties. These take about eight to nine months to complete their development, compared with the quickly maturing outdoor varieties (five or six months). Unrooted cutting treatment followed by two sprays, although successful in the main series, was not nearly so effective in the early-struck series.

General observations on varieties treated in the course of these experiments during the years 1951–53 showed that cuttings taken the following year from stocks treated with parathion often developed appreciable eelworm infestations if not treated again. There was also evidence of an appreciable increase in the incidence of Chrysanthemum Rust, *Puccinia chrysanthemi* Roze, on some nurseries which have changed over from warm-water treatment to parathion spraying.

SUMMARY

An economic but not complete control of Chrysanthemum eelworm can be achieved by the use of parathion. To control eelworm in mid-season and late flowering varieties, three applications are necessary : the first to the unrooted cuttings at the time of setting out, the second immediately rooting has taken place, and the last one month later. The strength of parathion is not critical between the limits of 0·005 per cent (4 fluid ounces of 20 per cent material per 100 gallons of water) and 0·025 per cent (20 fluid ounces of 20 per cent parathion per 100 gallons). Stool treatment was not satisfactory on indoor varieties.

A less extensive programme is needed for early outdoor flowering varieties. A satisfactory control can be obtained with two later sprays omitting the pre-rooting treatment. No information has been obtained as to whether pre-rooting treatment would give more satisfactory control in early varieties.

There is an indication that later striking of cuttings of indoor varieties may assist in reducing eelworm build up and increase the efficiency of control by parathion.

We wish to thank the various County Horticultural Officers and their staffs who arranged for experimental sites, and the growers who willingly co-operated in these experiments.

APPARATUS FOR RECORDING THE RATE OF SPORE DISCHARGE

by A. T. K. CORKE

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In the course of work at Long Ashton on the perennation of the Black Currant Leaf Spot fungus, *Pseudopeziza ribis* Kleb., it has been found that abundant apothecia develop on the dead leaves in the spring (Corke, 1954, 1955). Ascospore discharge has been studied by means of an apparatus in which the ascospores are trapped on agar in a slowly revolving petri dish.

The apparatus (Plate III, 2) consists essentially of a drum revolving inside a larger metal cylinder, both being attached to a wooden base. The drum, 5 in. dia. and 6 in. high, actuated by a clock mechanism causing it to revolve once in 24 hours, was part of an existing meteorological instrument, in which it carried a recording chart. The metal cylinder is 5½ in. dia., open at the top, and 1 in. higher than the top of the drum. The open petri dish is placed on top of the drum, and a glass plate, supported above it by the cylinder, carries the spore source. A rubber ring round the top of the cylinder provides a non-slipping surface for the plate.

Several small alterations were made to adapt the existing instrument. The knob was removed from the centre of the drum lid, leaving a flat surface, and a cardboard disc marked in intervals of 1 hour was then attached to this, with a smaller disc of rubber in the centre to hold the petri dish in the correct position. To remove the discs and the drum lid for winding the mechanism, a thread was tied to a bead and passed through a small hole in the centre. The metal strip which originally held the record chart on the drum was replaced by a small piece of metal for positioning the lid on the drum.

METHOD OF USE

A disc 1 cm in diameter is cut from part of a leaf bearing mature apothecia. This disc is placed upside down on a drop of agar on the white mark 1¼ in. from the centre of the glass plate (*see* Plate III, 2, right). The lower half of a marked petri dish containing agar is then placed on the drum, with the marks on the dish and the lid of the drum aligned with another mark on the cylinder. The glass plate is inverted and placed on top of the cylinder so that the leaf disc is suspended over the starting point.

To prevent spores discharged during the first hour from being confused with those discharged during the last, the petri dish is removed after 23 hours and replaced by another, if it is desired to continue the record. On removing the dish from the apparatus, a circle 2½ in. dia. marked at intervals of 1 or 2 hours from the starting point is drawn with a coloured pencil on the bottom of the dish. This line marks the centre of the spore trace and serves as a reference point during examination under the microscope of the surface of the agar. It also simplifies calculation of the approximate time at which any part of the agar passed beneath the leaf disc, and, therefore, of the rate of spore discharge. By using a petri dish with a diameter of at least 4 inches, the whole width of the deposit can be examined.

EXPERIMENTS WITH PSEUDOPEZIZA RIBIS

Infected black currant leaves were collected in the autumn and overwintered in special trays (Corke, 1955). Leaves were removed periodically during the spring and were wetted before being placed in a moist chamber at 72°F. The approximate time required for the apothecia to reach full maturity was determined by the density of the ascospore discharge from leaf discs cut at intervals. A further leaf was then removed from the trays, incubated for the required time, and a disc from it placed in the apparatus.

The results obtained showed that the incubation period required became progressively shorter as the season advanced, the apothecia maturing readily in the field during May. Although ascospore discharge was induced prematurely by prolonged incubation, the percentage germination was very low : both the number of ascospores discharged and the percentage germination rose to a maximum during May. Under suitable conditions spores were discharged for more than 24 hours, the rate decreasing during darkness and increasing with the return of daylight. No discharge occurred in continuous darkness.

It was found that the agar used for the collection of the ascospores provided sufficient moisture within the apparatus to prevent the leaf disc from becoming dry during the period of the experiment. The viability of the discharged ascospores was also readily assessed after 48 hours at 76°F.

IMPROVEMENTS AND OTHER APPLICATIONS

The method used in the study of ascospore discharge by apothecia of *Pseudopeziza ribis* could be employed in similar studies of spore discharge by other species of fungi, using numbers of fructifications or parts of fructifications from which spores are forcibly ejected. Lighter and smaller drums than that used in the prototype are available. The compactness of the apparatus makes it possible to enclose it in a bell jar, which would enable comparisons of the rate of spore discharge to be made under various conditions of temperature and humidity. The brass construction of most clock drums makes them suitable for use under humid conditions, and holes drilled in the cylinder would prevent its contents from being isolated from the surrounding atmosphere. Greater accuracy in estimating the time of spore discharge could be obtained in several ways : by using a drum revolving once in 12 hours instead of in 24 ; by reducing the size of the spore source ; or by reducing the distance between the spore source and the agar, thereby limiting the scatter.

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EFFECT OF 2:4:6-TRICHLOROPHENOXYACETIC ACID ON THE SUSCEPTIBILITY OF TOMATO PLANTS TO *DIDYMELLA LYCOPERSICI*

by H. E. CROXALL, THERESA M. NORMAN AND D. C. GWYNNE

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Following the work of Crowdy and Wain (1951) on the systemic fungicidal activity of aryloxyalkylcarboxylic acids, in which they showed that watering broad beans with 2:4:6–trichlorophenoxyacetic acid (2,4,6–T) increased their resistance to *Botrytis fabae* Sardina, we decided to test if the same chemical might be active in rendering tomato plants more resistant to *Botrytis cinerea* Fr.

In 1952, a preliminary experiment was carried out in a Northumberland glasshouse where *Botrytis cinerea* had frequently caused heavy losses of fruit. One group of eight plants was watered with 2,4,6–T at 500 p.p.m., a second group was watered with a solution of 8 hydroxyquinoline–5–sulphonic acid at 250 p.p.m., and a third group with 8 hydroxyquinoline sulphate. Each plant received approximately one quart of solution. A second series of groups of eight plants was sprayed with the same materials at the rate of one pint per plant. It was intended to give five applications at fortnightly intervals, but on June 23, the day before the date on which the third application was due, the nurseryman informed us that all the plants watered with 2,4,6–T were wilting. These plants were removed and were found to have basal lesions typical of those caused by *Didymella lycopersici* Kleb. The lesions bore characteristic pycnidia, and the diagnosis was confirmed by microscopic examination of the spores and by isolating the fungus in pure culture. Because of this outbreak of *Didymella*, the experiment was not carried further. No other plants in the house showed any symptoms of *Didymella* infection at any time during the growing season.

A parallel experiment was laid down at the headquarters of the Northern Province of the N.A.A.S., in a small glasshouse which had just been rebuilt. The borders had been resoiled with loam from a site where tomatoes had never been grown, but the soil was not sterilized. Each of the same treatments was given to two replicates of five plants, and there were also five plants in each series to which water only was applied as controls. The first applications were made on May 27, and four further applications were given at fortnightly intervals. The plants sprayed with 2,4,6–T developed severe leaf distortion typical of hormone injury, and those watered with 2,4,6–T showed similar symptoms but only to a slight extent. On July 24, all the plants were inoculated with *Botrytis cinerea* through stem wounds, and in every instance local lesions developed at the point of inoculation. In early August, plants watered with 2,4,6–T began to wilt and, by the mid-month, all ten plants bore *Didymella lycopersici.*

It was not possible to continue this work in 1953, but in 1954, after thorough washing down of the house with 2 per cent formalin, an experiment was laid down on plants grown in sterilized John Innes compost in new 10-inch pots. The treatments applied on September 3 and 20 to plants carrying five trusses were : 1 pint per plant of 2,4,6–T at 500 p.p.m. and 250 p.p.m. applied to the soil ; ½ pint per plant of 2,4,6–T at 250 p.p.m. sprayed on to the aerial parts of the plants ; and control, with water only. There were two replicates of seven

plants receiving each treatment. All the plants were watered with a suspension of *Didymella* spores the day after the first application of 2,4,6–T, and all were examined on October 26 and 30. Only two of the fourteen control plants and none of the plants sprayed with 250 p.p.m. 2,4,6–T were infected with *Didymella*. These latter plants showed no hormone distortion in this experiment. Eight of the plants receiving 2,4,6–T at 500 p.p.m. through the soil were infected and the remaining six were free from disease. Only one plant watered with 250 p.p.m. of 2,4,6–T was infected. These results were not so striking as in the previous years, but plant growth was almost complete when the experiment started.

We considered it possible that the increase in susceptibility to *Didymella* was due to the solution of 2,4,6–T causing external injury to the plant base, thus allowing the fungus to penetrate more easily. An attempt was made to eliminate this in our 1955 experiment by surrounding the bases of the plants with transparent plastic collars so that the solution used should not come into contact with the stem bases. The treatments used were : control ; 2,4,6–T at 500 p.p.m., 250 p.p.m. and 125 p.p.m. applied to the soil at the rate of 1 pint per plant ; and 2,4,6–T at 250 p.p.m. and 125 p.p.m. sprayed on the foliage at the rate of ¼ pint per plant. In the earlier experiments we had been surprised to see the growth-hormone effect produced by 2,4,6–T on the tomatoes, though Professor Wain has since informed us that this is normal. Although the material had been supplied by a source suggested by Professor Wain, we considered the possibility of some slight impurity being present and being responsible for some of the effects. Therefore, in this experiment, a small amount of 2,4,6–T was recrystallized from benzene and was also applied at 500 p.p.m. On one side of the glasshouse 5 randomized plants received each treatment, and a *Didymella* spore suspension was added immediately after the first treatment. In an attempt to obtain further information on the effect of 2,4,6–T in the absence of *Didymella* spores, the experiment was repeated in the opposite side of the house, but no spore suspension was added to the plants.

TABLE 1

EFFECT OF TREATMENT WITH 2,4,6–T ON THE SUSCEPTIBILITY OF TOMATO PLANTS TO DIDYMELLA LYCOPERSICI

Treatment	Inoculated Plants		Uninoculated Plants		Total No. of Plants with *Didymella* Infection
	Healthy	*Didymella* Infected	Healthy	*Didymella* Infected	
500 p.p.m. 2,4,6–T to soil	0	5	3	2	7
500 p.p.m. recrystallized 2,4,6–T to soil	1	4	1	4	8
250 p.p.m. 2,4,6–T to soil	1	4	2	3	7
125 p.p.m. 2,4,6–T to soil	0	5	2	3	8
250 p.p.m. 2,4,6–T to foliage	3	2	3	2	4
125 p.p.m. 2,4,6–T to foliage	2	3	2	3	6
Control	4	1	5	0	1

All the plants were grown in sterilized 10-inch pots of sterilized John Innes compost, and the house had been thoroughly washed down with formaldehyde during the winter. The first applications of 2,4,6–T were made on July 28 when

the plants showed three trusses, and the second a fortnight later. Removal of the plants from the glasshouse took place between August 22 and September 19 and the soil was washed from the roots. The results are given in Table 1.

It will be seen that there was considerable infection with *Didymella* in the uninoculated series, but this was not surprising as, in the earlier experiments, plants had become infected even when the fungus had not been deliberately introduced into the house, and in this experiment there was only a short distance between the inoculated and uninoculated plants. Only one plant in the inoculated control pots was infected, indicating that these plants possessed some degree of resistance to the disease. This resistance was reduced by all the 2,4,6–T treatments, and to the greatest extent when the solutions were applied to the soil. The roots and stem bases of both healthy and infected plants were carefully examined for any trace of injury, and the only sign of damage was in the plants receiving 500 p.p.m. 2,4,6–T through the soil, where there were more brown roots than in the controls. The increased infection in the sprayed plants also indicates that root-injury by the chemical was not a major factor.

TRIALS IN 1956

In 1956, an experiment was carried out with plants in soil blocks of John Innes compost. On April 26, when the plants were in the six true leaf stage and showing the first flower truss, groups of four plants were stood in metal trays into which were put one pint of solutions of 2,4,6–T of the following strengths: 250 p.p.m., 125 p.p.m., 80 p.p.m., 60 p.p.m., 40 p.p.m., 20 p.p.m., 10 p.p.m., 4 p.p.m., 2 p.p.m., 1 p.p.m. There were two groups as control trays and these received only water. Round the stem bases was poured a suspension of *Didymella* spores. In a second, similar series no spore suspension was added. Symptoms of *Didymella* infection were noted in some plants a month later. All the plants were examined on June 18–20 and the results are given in Table 2.

TABLE 2

EFFECT OF WATERING TOMATOES WITH VARIOUS STRENGTHS OF 2,4,6–T

Strength of 2,4,6–T *p.p.m.*	Inoculated		Uninoculated		Total No. of Plants with *Didymella* Infection
	Didymella Infected	Healthy	*Didymella* Infected	Healthy	
250	2	2	0	2*	2
125	3	0*	3	0*	6
80	4	0	1	3	5
60	4	0	2	0*	6
40	0	0*	3	0*	3
20	0	4	0	4	0
10	0	4	0	4	0
4	1	3	0	4	1
2	1	3	0	4	1
1	1	3	0	4	1
0 (control)	1	3	0	4	1
0 (control)	0	4	0	4	0

* Remainder of the 4 plants infected with *Phytophthora* sp.

In considering these results, it must be remembered that *Didymella* infection is seldom seen in such young plants under normal glasshouse conditions, and only one out of the eight control plants which were watered with a spore suspension was infected. Strengths of 2,4,6–T down to 40 p.p.m. gave more infection, though the highest strength of 250 p.p.m. was not as effective as would be expected from the earlier results. It is also interesting to note that *Phytophthora* infection was found in some plants receiving 2,4,6–T at strengths of 40 p.p.m. and above, but not in the controls or in the strengths below 40 p.p.m.

A further experiment was made in 1956 to investigate the effect of a range of concentrations of 2,4,6–T on older plants. As in previous years, these were grown in sterilized John Innes compost in 10-inch pots. The following concentrations were used: 0 (control), 25 p.p.m., 50 p.p.m., 100 p.p.m., 150 p.p.m., and 200 p.p.m. Each solution was applied to a group of twelve plants at the rate of 500 c.c. per plant on July 19 when the plants were carrying three trusses. On July 26, half the plants were given a second application. The plants were examined from August 21 to 28, with results as shown in Table 3.

TABLE 3

EFFECT OF WATERING TOMATOES WITH VARIOUS STRENGTHS OF 2,4,6–T

Strength of 2,4,6–T *p.p.m.*	One Application of 2,4,6–T			Two Applications of 2,4,6–T		
	Didymella Infected	*Phytophthora* Infected	Healthy	*Didymella* Infected	*Phytophthora* Infected	Healthy
200	1	1	4	3	5*	1
150	3	0	3	6	2†	0
100	5	0	1	4	2‡	1
50	2	0	4	4	2‡	1
25	3	0	3	2	0	4
0 (control)	0	0	6	0	0	6

* 3 plants, † 2 plants, ‡ 1 plant with both *Didymella* and *Phytophthora*.

There is a remarkable similarity between these results and those of the previous experiment. *Didymella* infection occurred in each series except those receiving water only, and the highest numbers of infected plants occurred in the series receiving 50, 100 and 150 p.p.m. 2,4,6–T. Again, there was less infection at the highest concentration of 200 p.p.m. In the series receiving two applications of solution, it is interesting to note the appearance of *Phytophthora* infection in plants receiving 50 p.p.m. or more of 2,4,6–T, as this also occurred in the previous experiment. In the series receiving a single application at 200 p.p.m. one plant was also infected with *Phytophthora*. It would appear that the possibility of increasing susceptibility to this and other fungi merits further investigation under controlled conditions.

DISCUSSION

It is realized that in all these experiments the numbers of plants involved have been, because of lack of space, fewer than is desirable. Yet the repetition of similar results over four seasons strongly indicates that the application to tomato plants of 2,4,6–T solutions of strengths from 500 p.p.m. to 40 p.p.m., increases their susceptibility to infection by *Didymella lycopersici*. There is some indication in the 1956 experiments that there may also be increased susceptibility to *Phytophthora* spp. The first experiments suggested that *Didymella* spores were present in tomato houses with no known previous history of the disease, and where there was no obvious nearby source of infection. Our results show that, under the conditions in which these experiments were carried out, the close proximity of *Didymella* spores to the bases of tomato stems does not necessarily cause infection. This is in agreement with our observations that, in the Northern Province, although occasional plants infected with *Didymella* are often found in nurseries, there is little or no secondary spread. The only exception to this was in one nursery in 1955, when temperatures and sunlight were much above normal in the north. The addition of 2,4,6–T appears to break down the natural resistance of the tomato plant to infection. The mechanism of this process is unknown, and, so far, we have found no evidence that it is due to external injury to the plant tissues.

The results appear to be in agreement with the suggestion of Wain and his co-workers (Wain, 1951 ; Fawcett, Spencer and Wain, 1955), that the systemic fungicidal activity of the arylcarboxylic acids may be due to their effect on the host rather than directly on the parasite. They also support the opinion held by these workers that these substances might make a host plant more, as well as less, susceptible to a disease. The results we have obtained require further investigation, but they indicate that there may be a danger in the widespread use of systemic fungicides of this type against one disease, without first determining whether they make the host plant more susceptible to other diseases.

We are grateful to our Scientific Assistant, Mr. W. A. Davey, for his help in carrying out these experiments and in preparing plants for examination.

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PRELIMINARY FIELD TRIALS WITH STREPTOMYCIN FOR THE CONTROL OF BACTERIAL CANKER OF CHERRY

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In the bacterial canker disease of cherry, *Pseudomonas mors-prunorum* Wormald, a summer phase in the foliage (leaf spot) alternates with a winter stage in the stem and branches (canker). Control measures devised by Montgomery and Moore (1945) aimed at breaking this cycle with bactericidal sprays in the spring and autumn when, for short periods, the two phases of the disease overlap. Using Bordeaux mixture for this purpose they achieved sufficient control of both leaf spot and canker to recommend the routine use of this programme in commercial orchards. Experience has borne out the value of these sprays, but Bordeaux mixture has not won universal favour because of its phytotoxicity, particularly on young nursery trees, and also because of its deleterious effects on spray machinery. The need for alternative bactericides, less disadvantageous in these respects, has been apparent for some time.

In recent years, there have been reports of the successful control with streptomycin of several bacterial plant diseases, including some important diseases of tree-fruits, notably Fire-blight (*Erwinia amylovora*), (Winter and Young, 1953) and others, and Stone-fruit Blast (*Pseudomonas syringae*) (Dye, 1954 ; Chamberlain, 1954). From 1954 to 1956 inclusive, preliminary field trials have been carried out at East Malling Research Station to assess the value

of streptomycin for the control of bacterial canker of cherry. A brief account of these trials follows. The inhibition of leaf spot infection obtained in a glasshouse experiment by spraying with streptomycin is shown in Plate II, 1.

EXPERIMENTAL METHODS

The tests were duplicated on the two varieties Napoleon and Roundel, of low and high disease resistance respectively. The trees, low-worked on F12/1 rootstocks, were planted as maidens in December 1951 in a randomized block system giving 12 replicated single tree plots per treatment for each variety. In 1955, and again in 1956, the treatments were re-allocated to the experimental trees in such a way as to make the tests independent of those in the preceding year. This also made it possible to test for any long-range effects due to the sprays.

The sprays were applied (1) in the spring, during the blossom period, for the control of leaf infections and (2) in the autumn for the control of branch and stem infections. In autumn 1954, streptomycin was used as the sulphate (potency approximately 720 i.u. per mgm) at a concentration of 200 p.p.m. (0·908 g of the salt per gallon). All other sprays were of streptomycin hydrochloride at a potency of 220 i.u. per ml (1 g streptomycin base equivalent per gallon). Agral L.N. was incorporated as a spreader at 0·05 per cent v/v in 1954 and at 0·066 per cent v/v in the remaining sprays. Sprays were applied at high volume to " run-off ", using a lance to give complete coverage.

Since the data on the severity of leaf infection were required in other investigations, this phase was recorded in considerable detail by counting the spots on the leaves of every fourth fruiting spur. Severity was then expressed as the number of spots per hundred leaves. A simple category method is usually adequate for assessing leaf spot but is too insensitive in years when leaf infections are comparatively light.

All canker infections recorded in these experiments occurred on branches. Over 99 per cent of these were associated with fruiting spurs or with the nodes on the one-year-old wood, and were the result of autumn infection through leaf scars in the autumn (Crosse, 1956). The size of lesions arising from this type of infection varies from small localized necroses in the region of the leaf scar to large cankers several inches long which may encircle and kill the branch (Crosse, 1955). Counts were made of (1) total branch and stem infections of all kinds, (2) infections giving rise to branch cankers, (3) branches showing " die-back ". Spur and nodal infections were recorded separately, because under field conditions they are infected independently of one another (Crosse, 1955). This gave, with two varieties, four separate tests each year of the effect of the streptomycin sprays.

No chlorosis or any other leaf damage resulted from spring sprays, and they had no apparent effect on blossom set. In contrast to Bordeaux mixture, there was no acceleration of leaf fall from the autumn streptomycin sprays.

Treatment effects were compared by analysis of variance, using a log transformation for leaf infection and a log $(n + 3/8)$ transformation for branch infections. The data shown in the tables below are the arithmetic means per tree.

EFFECT OF AUTUMN SPRAYS AGAINST BRANCH INFECTIONS

In 1954, two sprays of streptomycin sulphate (200 p.p.m.) were applied on September 23, the first in the morning, the second in the afternoon. The second

spray was applied because the first was probably removed before it was dry by very heavy rain which fell immediately after application. Control trees were unsprayed. The incidence of spur and nodal infections on branches, as recorded in May 1955, is shown in Table 1. There was a considerable reduction in both spur and nodal infections amounting to virtually complete control for cankers on Napoleon ; there were only 4 instances of die-back, all on unsprayed trees of Napoleon. Streptomycin appeared generally less effective on the more resistant variety Roundel.

In 1955, the trees were sprayed on September 2 and again on October 4, with streptomycin hydrochloride (220 i.u. per ml). Control trees were sprayed with water plus agral L.N. Spur and nodal infections were recorded in May 1956 (Table 1). There was no evidence from the analyses of any residual effects from the previous year's treatments. On the basis of the total numbers of spur and nodal infections, the level of control was about the same as in the previous year, the streptomycin again proving less effective on the variety Roundel.

TABLE 1

EFFECT OF STREPTOMYCIN SPRAYS ON BRANCH INFECTIONS (MEANS PER TREE) ON THE CHERRY VARIETIES NAPOLEON AND ROUNDEL, 1954–55, AND 1955–56

		Napoleon			Roundel		
		Control	Strepto-mycin	Reduction per cent	Control	Strepto-mycin	Reduction per cent
1954–55 Streptomycin sulphate (200 p.p.m.)							
Total no. of infections	Spurs ..	14·5	4·8	66·9***	4·3	2·1	51·2*
	Nodes ..	5·1	0·6	88·2***	0·6	0·2	66·7
		19·6	5·4	72·4***	4·8	2·3	52·1**
Cankers	Spurs ..	1·7	0·1	94·1†	3 cankers only on the entire plot, 2 of which were on unsprayed trees.		
	Nodes ..	1·3	0·0	100·0†			
		3·0	0·1	96·7***			
1955–56 Streptomycin hydrochloride (220 i.u. per ml)							
Total no. of infections	Spurs ..	11·8	3·5	70·3***	7·7	3·9	49·4***
	Nodes ..	3·3	1·2	63·6	5·2	1·3	75·0**
		15·0	4·7	68·7***	12·8	5·3	58·6
Cankers	Spurs ..	1·9	0·7	63·2***	0·2	0·0..	100·0†
	Nodes ..	1·6	0·7	56·3	1·8	0·8	55·6*
		3·5	1·3	62·9**	1·9	0·8	57·9†

† Not analysed. * Significant at P = 0·05; ** at 0·01; *** at 0·001.

The trees sprayed with streptomycin had previously received spring sprays of the antibiotic for the control of leaf spot (Table 2), and these may have contributed towards the control of branch infections. This is known to occur with Bordeaux mixture (Montgomery and Moore, 1945), where the effect of spring sprays is probably to reduce the amount of inoculum available in the autumn.

There were indications, particularly on Napoleon, that streptomycin was less effective in preventing the more serious forms of the disease. Thus the numbers of cankers were not reduced to the same extent as the total numbers of infections. There were 8 instances of branch die-back on the treated trees of Napoleon,

compared with 12 on the controls—a reduction of only 33·3 per cent. Only small lateral branches were involved on the treated trees, however, whereas three of the control trees were severely mutilated by cankers which destroyed the main branches. Die-back was virtually absent on the variety Roundel.

SPRING SPRAYS AGAINST LEAF INFECTIONS

In 1955, streptomycin hydrochloride (220 i.u. per ml) was applied during the blossom period. This roughly coincides with the expansion and development of the young leaves and is now regarded as an important period for leaf infection. Control trees were unsprayed. The details were as follows :

	Date	Blossom Stage	Length of Leaves (cm)
First spray	May 6	full bloom	3–4
Second spray ..	May 11	75% petal-fall	5–6
Third spray ..	May 16	100% petal-fall	6–7

Blossom stage and leaf length are for the variety Napoleon ; Roundel was slightly in advance of this. The results of the sprays were recorded after about 6 weeks and are shown in Table 2. The analysis of variance provided no evidence of any residual effects from the previous years treatments. The severe leaf spotting on the control trees, resulting from the exceptionally wet weather during blossom, was almost completely controlled by the three streptomycin sprays. By mid-June the contrast in appearance between the sprayed and unsprayed trees was most striking.

TABLE 2

EFFECT OF STREPTOMYCIN HYDROCHLORIDE (220 I.U. PER ML) ON THE INCIDENCE OF LEAF INFECTIONS (MEAN NO. OF SPOTS PER 100 LEAVES PER TREE) ON THE CHERRY VARIETIES NAPOLEON AND ROUNDEL IN 1955 AND NAPOLEON IN 1956

	Control	Streptomycin	Reduction per cent
Napoleon, 1955..	262·1	9·0	96·6*
Roundel, 1955 ..	146·6	10·0	93·2*
Napoleon, 1956..	36·8	3·7	89·9*

* Significant at P = 0·001.

In 1955, trees were sprayed twice during the blossom period with streptomycin hydrochloride (220 i.u. per ml), as follows :

	Date	Blossom Stage	Length of Leaves (cm)
First spray	May 8	20% petal-fall	4–5
Second spray ..	May 14	90% petal-fall	6–7

The amount of leaf spot as recorded in June is shown in Table 2 for the variety Napoleon only : leaf spot on Roundel was too scarce for adequate records. Leaf spotting was less severe than in the previous year because of the dry weather during the blossom period ; the level of control, however, was about the same as in 1955. There were some residual effects from the previous year's treatments, the trees receiving streptomycin in 1955 having significantly less (P = 0·01) leaf spot than the control trees. However, the same effect was observed on trees sprayed with Bordeaux mixture in 1955 and is attributed to the reduction by the 1955 sprays of the number of overwintering infections available for infection of the leaves in the spring of 1956.

DISCUSSION

In two independent tests carried out in 1954 and 1955, two autumn sprays of streptomycin, possibly assisted by spring sprays in 1955, reduced the total number of branch infections on the variety Napoleon by more than two-thirds and on the more resistant Roundel by slightly more than one-half. In the second year's trial, there were indications that streptomycin was more effective against the milder types of infection than against the more severe forms such as die-back. The evidence was not conclusive, however, and further field trials will be necessary to see whether or not this tendency is maintained.

Comparisons with previous trials suggest the control with streptomycin to be slightly superior to that obtained with two autumnal sprays of 10–15–100 Bordeaux mixture. The margin of difference, however, is not very great and final conclusions on the relative merits of the two materials must await direct comparison within the same trial.

Streptomycin was highly effective against the leaf spot phase of the disease and appears to be superior to Bordeaux mixture for this purpose. The streptomycin was applied during the blossom period, whereas the use of Bordeaux mixture has hitherto been restricted to the immediate pre-blossom and post-blossom stages because of spray damage. The greater effectiveness of streptomycin may therefore be related to time of application and not necessarily to superior bactericidal or to other properties.

It must be emphasized that these experiments were made on young trees using a lance to obtain complete coverage of the foliage with the sprays. Under commercial conditions coverage is apt to be less adequate, especially on older trees, and this probably reduces the effectiveness of surface bactericides such as Bordeaux mixture. The same limitations may well apply to streptomycin, unless, of course, it acts systemically in cherry, as it does in dwarf bean against *Ps. phaseolicola* (Mitchell *et al.*, 1954; Napier *et al.*, 1956). On this there is yet no evidence.

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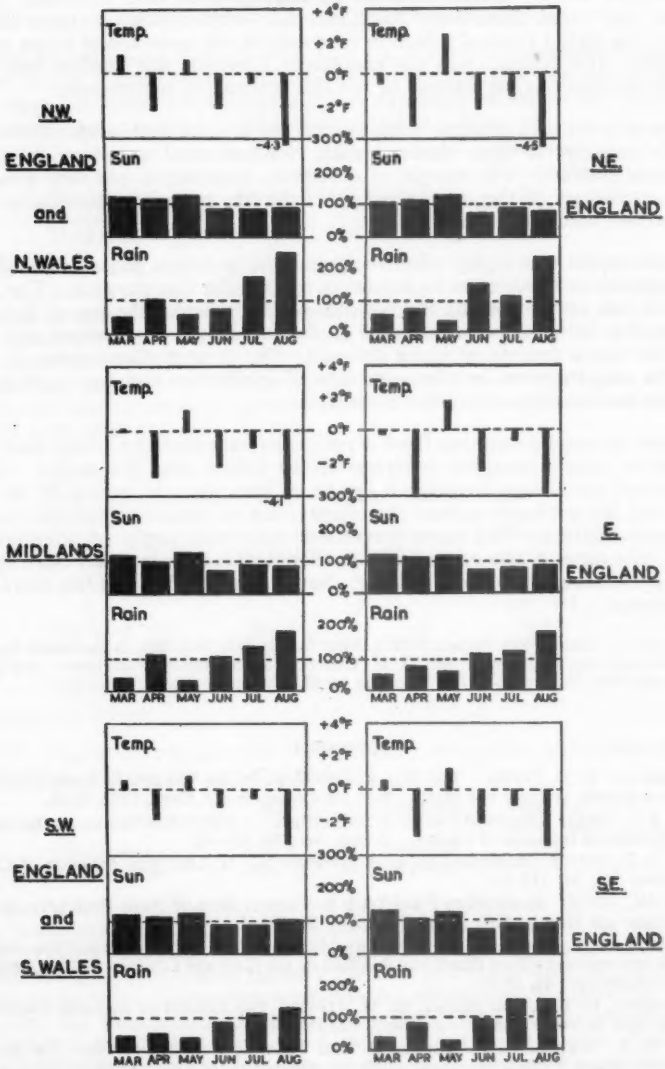
MARCH-AUGUST WEATHER 1956

Variations from average



THE WEATHER OF ENGLAND AND WALES*

SPRING AND SUMMER, 1956

The outstanding feature of the spring weather was its dryness. The percentages of average rainfall that fell over England and Wales as a whole were 46 in March, 75 in April and 41 in May. Sunshine amounts were, as a fairly usual but not inevitable corollary, above average in all districts in each month. Following the very cold February conditions, mean temperatures in March increased to just above average, but April was a cold month, particularly in eastern England. South-easterly winds prevailed during most of March, and in April the usual westerlies were still absent, being replaced by periods of calm and light variable winds. Inland, mean wind speeds for the month were only about 5 or 6 knots. May was warm, especially in the north-east ; extreme temperatures of 82°F were reached in London on the 28th. Late frosts, not uncommon in a dry spring, occurred between the 17th and 20th ; a night minimum of 23°F occurred at Stony Stratford on the 19th.

The dry, sunny spring was followed by a cool, wet, cloudy summer. Sunshine was deficient in each month everywhere, except in the south-west during August. The mean temperature of each month was below average, August in particular bringing some very low daytime maxima. There has been no colder August in England and Wales since 1912 ; day maxima at the end of the month were as much as 10° below normal. There was considerable rain, especially in July and August and in areas of Yorkshire, Lancashire and the northern counties. In parts of the north-west it was the wettest August for over 100 years. The summer rainfall was peculiar in that most of the rain fell quickly over short periods of time ; the duration of rain was therefore short in relation to the high totals. The net result of such weather was probably to increase the rapid run-off of water and to decrease any deep percolation.

The weather in each of the six months March to August (inclusive) is represented graphically on page 36. Figures for six districts of England and Wales are shown in terms of deviation from average for air temperature, sunshine and rainfall. These histograms clearly show the dryness of the spring and the wetness of the late summer. The persistent absence of high average temperatures is also illustrated, May being the only exception. Relatively speaking, August was the month in which the weather was most cool in comparison with normal conditions, and this was almost entirely due to the absence of daytime warmth.

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* These notes, and the diagram on page 36, are provided by the Agricultural Branch of the Meteorological Office, and published by permission of the Director.

NEW OR UNCOMMON PLANT DISEASES

***Pseudoplea trifolii* on Lucerne.** *Pseudoplea trifolii* (Rostr.) Petrak (syn. *Sphaerulina trifolii* Rostr.) has been recorded previously only on white clover in Britain, the disease being known as Burn. In the U.S.A., the closely related species, *P. medicaginis* Miles and *Pleosphaerulina briosiana* Poll., produce similar symptoms on bur clover and lucerne respectively. Distinction between these species rests purely on slight differences in perithecium, ascus and spore measurements (Miles, L. E., *Phytopathology*, 1925, **15**, 677–89) and they have been regarded by Horsfall (*Mem. Cornell agric. Exp. Sta.*, 1930, No. 130, 139 pp.) as one species.

In July 1956, symptoms similar to Burn were noted on certain spaced, single plants of lucerne in field trials at the Welsh Plant Breeding Station, Aberystwyth Leaves of affected plants bore numerous light brown lesions, with a darker rim (Plate III, 1). Many of these lesions bore small immersed perithecia which, on microscopic examination, appeared typical of those of *Pseudoplea trifolii*, containing broadly ovate asci, without paraphyses, but with eight triseptate ascospores. Detailed measurements of asci and spores were not made, and in view of the complicated synonymy, it would appear best at present to regard the causal organism as *P. trifolii*.

The Aberystwyth area is at the perimeter of lucerne growing in Britain, so that it has not been possible to record the incidence of the disease over a wide area or in normal stands. Among spaced plants it was remarkable to note how whole families had been affected, the rows being readily picked out from the unattacked neighbouring rows by virtue of their yellowish-brown burnt appearance and, in the most severely infected plants, the very great amount of leaf shedding. Within affected rows, differences in severity of symptoms were evident between the various members of the family, but these differences were of less significance than those between families.

The apparent genetic difference between infected and uninfected families is further substantiated by the following observation. The families in trial on the field were the progeny of a diallel cross in which one parent was derived from a cross between a plant of the Canadian variety Rhizoma and one of the Aberystwyth bred S.205. Only those families derived from this particular parent were affected. The Rhizoma material was imported as seed. However, these observations suggest that resistance and susceptibility are under fairly strict genetic control.

A. J. H. CARR

***Botrytis anthophila* on Red Clover.** Anther mould of clover caused by *Botrytis anthophila* Bondartzev is rarely recorded in Great Britain from plants in the field, yet a high proportion of red clover seed samples of the 1955 English harvest recently examined in Scotland were infected. Only one sample from the 1956 English harvest has so far been available for examination, and this has proved to have 50 per cent infection.

MARY NOBLE

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